Knowledge transfer in shipbuilding projects:

A study of facilitating mechanisms

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ABSTRACT

This research provides insight into the important role of experienced sailing officers in shipbuilding projects. The aim of this exploratory case study was to develop an understanding of mechanisms used to facilitate knowledge transfer. We identify five shipbuilding phases as scoping, specification, negotiation, construction, and acceptance testing. Further we identify the important role of experienced sailing officers in knowledge transfer between ship owner, shipyard, and the shipbuilding project. The original value of the paper is the use of knowledge management theory to extend the scientific research and theory of shipbuilding and to inform project managers on knowledge transfer mechanisms.

Keywords: shipbuilding project, knowledge transfer, knowledge transfer mechanisms

INTRODUCTION

Building ships on time, within budget and fulfilling technical requirements are important factors in commercial shipbuilding. However, experience has shown us that shipbuilding projects sometimes have difficulties reaching these goals because they do not employ best practice. Setting ambitious requirements, new designs often making little use of prior ship designs, starting construction without a stable design, are all examples of inefficient practices causing ships to cost more than they otherwise should (Francis, 2009). To ensure that design and construction of a ship can be executed as planned, the shipyards and buyers must not move on until critical knowledge is attained. We will argue that innovative shipbuilding is a complex and knowledge intensive industrial activity. According to Wang et al. (2008), knowledge constitutes a key strategic resource for shipbuilding organisations. It is an asset that can prove vital in an increasingly more competitive shipbuilding market. Consequently, the effective management of knowledge has become a critical organisational capability for both the ship buyer and the shipyard. Knowledge embedded in the project processes and the employees' skills provide the companies with unique capabilities to deliver successful projects.

In shipbuilding projects there is a need for transferring users' knowledge to the development process, especially in the key shipbuilding phases. However, in many circumstances, we believe that knowledge in the shipbuilding industry is mostly tacit knowledge and highly based on individuals' experience and perceptions. Another problem is that knowledge transfer across projects is difficult due to, for example, lack of practice, and pressure of time and a formal knowledge transfer system. As a consequence, as each new project is started, there is a tendency to "reinvent the wheel", rather than learn from the experiences of previous projects (Ajmal et al., 2009; Ruuska and Vartiainen, 2005).

Shipbuilding projects represent an industry that seems very well suited for knowledge transfer research. Often there are similarities between the ships and experience from previous shipbuilding projects can be helpful (Kim and Seo, 2009). Further, improved knowledge transfer could be useful to help the companies improve their processes and create total value (Dwivedi and Maffioli, 2003). From this, it follows that it is essential for individuals and teams working for project-based companies to acquire and draw upon the knowledge created by other individuals and teams (Ajmal et al., 2009). This means that project-based companies have to con-

sider features and mechanisms that facilitate transfer and sharing of created knowledge to other teams and organisational units of the firm.

Transfer of knowledge within and among organisations has been examined in numerous empirical studies within different industries (Kim and Seo, 2009). The study presented in this paper focuses on knowledge transfer in innovative shipbuilding projects, while contributing to the body of empirical knowledge management research. The aim is to identify and study mechanisms supporting improved knowledge transfer. We argue that effective transfer and use of knowledge from prior shipbuilding projects and from operations at sea to the shipyard reduces errors, creates less work, generates fewer questions, produces better decisions, and reinvents fewer wheels.

KNOWLEDGE AND KNOWLEDGE TRANSFER

The term knowledge has been defined in a number of ways in the published literature. According to Davenport and Prusak (1998), knowledge is "created by human interaction with information: each individual's interaction with information can bring about different interpretations depending on their previous experience and current abilities." Another definition is given by Nonaka and Takeuchi (1995) states that "knowledge is a dynamic human process of justifying personal belief toward the truth." From these definitions we can deduce that knowledge is based on data and information, but unlike these, it is always bound to individuals. Knowledge is personal and a construction of reality rather than something that is true in a universal way (von Krogh et al., 2000). There are two main types of knowledge that are important to distinguish between: tacit and explicit knowledge. Tacit knowledge is described as personal, hard to formalise and hard to communicate to others (Nonaka and Takeuchi, 1995). The other type of knowledge, explicit knowledge, is described by Nonaka and Takeuchi (1995) as transmittable in formal, systematic language. It is a type of knowledge that is easier to transfer since it can be expressed in words and numbers in manuals, patents, reports, documents, assessments and databases.

Dalkir (2005) argues that knowledge management is the deliberate and systematic coordination of an organisation's people, technology, processes and organisational structure in order to add value through reuse and innovation. Furthermore, he claims that this coordination is achieved through creating, sharing and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organisational learning. There are various knowledge management models that have been developed in the literature to support knowledge management activities in different industries (Ahmad and An, 2008). A significant element of knowledge management is the knowledge transfer process. Argote and Ingram (2000) define the term knowledge transfer as "knowledge transfer in organizations is the process through which one unit is affected by experience from another." Knowledge transfer, i.e. making use of existing knowledge, can be realised through two different approaches (Davenport, 1997):

- *The pull approach*: Knowledge seekers will access the proper knowledge source whenever they come across a problem or need a solution. The challenge here is to know where to search.

- *The push approach*: This approach deals with providing knowledge, experience or insight to other organisational members once it is developed or obtained firsthand. The challenge here is to know what others need.

When considering the application of the pull and push approaches, many organisations practice a combination of them (Davenport, 1997). However, to establish or know the conceptual difference, it can be useful to look at different mechanisms to deal with transferring of knowledge.

Knowledge transfer in project-oriented firms

When studying knowledge transfer in project-oriented firms it is important to distinguish between main paths on which the knowledge can be transferred. According to Salter (2003) three main paths are: 1) from one project to another parallel or subsequent project, 2) from one project to central or supportive units (e.g. project office) in the base organisation, and 3) from the base organisation to the project.

In a project-oriented firm the project organisations are often distanced from the other main supportive functions such as finance, IT, human resources, etc. The projects are often located in separate locations and it is only the managers of the projects that communicate with the main functions of the firm. The main form of knowledge transfer is information in a rigid form where there are systems for continuous reporting from the project to the base organisation. According to Drejer and Vinding (2006), studies have shown that this temporary nature of relations can pose problems in relation to continuous learning at the firm level, because there are no automatic mechanisms guaranteeing the transfer of knowledge between the project and firm level.

Leseure and Brookes (2004) claim that the management of knowledge between projects is often insufficiently prioritised in project-oriented firms. Knowledge is generated within one project, and then forgotten. As a result the same knowledge must be acquired again and again. This "reinvention of the wheel" is costly and time-consuming, and prevents the firm from learning and reusing best practice (Ajmal et al., 2009; Ruuska and Vartiainen, 2005).

The transfer and sharing of knowledge in project-oriented firms has proven to be a challenge (Gann and Salter, 2000). This is due to the nature of these types of firms: the dispersed organisation, the time pressure, the changing environments, limited resources, and the temporary management structure. The firms usually have forward focus and forget how important it is to gather information from previous projects. Whether the knowledge is passed on often depends solely on the composition of the next project team; what knowledge and experience the individual team members bring with them from previous projects. Schindler and Eppler (2003) have identified lack of time, motivation, discipline and abilities as four main reasons why firms do not manage to document and transfer their knowledge. This observation is in line with Disterer (2002) who claims that the motivation for documenting and transferring lessons learned is lacking and this type of work is not given enough credit. According to Schindler and Eppler (2003), experiences are not noted down during the project period, individuals do not see the usefulness of writing down their experiences, it is hard to coordinate post-project evaluation meetings, there is not enough willingness to learn from others' mistakes, and knowledge is not being archived in a way that is easily accessible.

However, the challenges in facilitating knowledge transfer and sharing across projects are well recognised (Boh, 2007; Brusoni et al., 2001) and many project-oriented firms have looked for solutions to successfully share knowledge across individuals and projects. To enable effective transfer and sharing of knowledge across projects, knowledge transfer and sharing mechanisms are the means by which individuals access knowledge and information from other projects (Boh, 2007). These mechanisms can be defined as the formal and informal mechanisms for transferring, sharing, integrating, interpreting and applying know-what, know-how, and know-why embedded in individuals and groups that will help in the perfor-

mance of the project tasks. Boh (2007) presents a framework that classifies the knowledge transfer and sharing mechanisms, where he differentiates between personalisation versus codification, and individualisation versus institutionalisation. According to Ajmal et al. (2009) personalisation mechanisms are often assumed to be more ad hoc and informal, while codification mechanisms are assumed to be formal, often with use of electronic databases. Individualisation versus institutionalisation distinguishes between mechanisms that enable the transfer and sharing of knowledge at the individual level versus at the collective level. While individualised mechanisms tend to be informal and unstructured, institutionalised mechanisms tend to be formal and embedded in organisational routines, procedures, systems and structures.

There are several practical mechanisms for knowledge transfer and sharing that focus on a personal exchange of knowledge. Previous research has identified mechanisms, such as personal network, mentoring, project reviews or post-project evaluation, brainstorming processes, job-rotation, meetings between project team and within project teams, meetings in the firm, common project director shared across projects, and support centres, that are applying either individualised or institutionalised mechanisms for knowledge transfer (Boh, 2007; Salter, 2003).

Personalised mechanisms represent a rich medium for communication, which is better because it enables the customisation of information to suit the context and the more it enables interaction to seek clarification and aid further reinterpretation of the knowledge (Boh, 2007). This view is in line with Koskinen et al. (2003) who claim that personal interaction is particularly appropriate for complex projects because it allows the project members to immediately and continuously discuss and solve problems that may appear during the project period.

Codification can be a good mechanism for storing large amounts of knowledge and for creating an organisational memory for all employees (Boh, 2007; Goodman and Darr, 1998). For example, many firms have implemented information and communication technology (ICT) solutions such as project databases, intranets and databases with lessons learnt. These are formal mechanisms that focus to a large extent on information and explicit knowledge. However, a lack of distinction between information and knowledge represents a criticism towards ICT solutions for the management of knowledge. Furthermore, it is a weakness that this mechanism does not allow interactions and customisation of solutions to the knowledge seeker's problems. ICT solutions can be a knowledge transfer mechanism, but never a replacement for social interaction.

RESEARCH METHOD

According to Mason (2002), an enquiry into understanding is well-suited for a qualitative research methodology. This methodology with case studies is especially useful for exploratory research where an in-depth understanding of a phenomenon in its context is desired (Yin, 2009). When exploring mechanisms for knowledge transfer, the search for meanings calls for an interpretive approach. An interpretive paradigm therefore seemed best suited for describing a rich and detailed view of how mechanisms based on the respondents' practical experience and insight support knowledge transfer in shipbuilding projects.

We selected the Siem Offshore new building programme for our study using information-oriented (purposeful) sampling (Patton, 2002; Flyvbjerg, 2006). The case was selected due to its expected capacity for information and knowledge about mechanisms facilitating knowledge transfer. The choice of case was made because it was expected to advance our understanding. The Siem Offshore case provides a broad base of shipbuilding practice. The

case involved the study of two main organisations; Siem Offshore, which is the buyer and owner of the vessels to be built, and Kleven Maritime, which is the contractor and shipyard.

Siem Offshore is an owner and operator of modern support vessels for the global oil and gas service industry. The company has grown significantly and currently has a fleet of 44 vessels, of which 14 are under construction. The company's fleet includes large anchor handling tug supply vessels (AHTS vessels), platform supply vessels, and other support vessels. Kleven Maritime is a technology-focused shipbuilding company whose primary activities include the fitting out and delivery of specialised vessels. Kleven Maritime has great expertise in project management and extensive experience of shipbuilding.

The new building programme studied includes ten AHTS vessels to be built and delivered during 2006–2011. The vessels are very large capacity AHTS vessels designed for towing and anchor handling, deepwater inspection and construction work. The design also enables clients to carry out regular supply and support duties for the offshore industry worldwide. The vessels are of clean design, comfort class, environmentally friendly and optimised for low fuel consumption through hybrid diesel electric and mechanical arrangements. Project cost (for each vessel) is around US $ 100 million. As such, the shipbuilding project is characterised by explicit goals, limited resources, temporariness (start and stop date), uniqueness, and cross sectionalism.

In-depth interviews following a semi-structured approach were employed as the data collection method. Eight people were interviewed altogether, six from Siem Offshore and two from Kleven Maritime, as listed in Table 1. Most interviewees were selected from the project organization, but with some interviewees outside representing the base organization and the supplier. The type of qualitative interviews that we used was one-on-one interviews (Patton, 2002). The duration of each interview was between 1 and 2 hours. The same researcher conducted all the interviews to assure consistency. The interviews were conducted face-to-face, and when necessary, follow-up emails were exchanged to discuss unclear data. Each interview was documented as soon after the interview as possible to preserve accuracy.

For the purpose of this study we used a content-analysis approach, as data needed to be analysed and interpreted (Patton, 2002). In the analysis we looked for and identified pertinent patterns and similarities in the responses. In addition to interviews, a literature review was conducted to explore the research front about effective knowledge transfer in projects. By cross-referencing the results from the interviews and the literature review, a refined list of mechanisms describing knowledge transfer was derived as research findings.

Table 1. *Interviewees and their background and experience*

Interviewee	Background	# shipbuilding projects	# year as officer
Ship owner HR director	Management, naval academy	n/a	n/a
Ship owner project director	Seaman, chief engineer	24	15
Ship owner project manager	Seaman, captain	13	16
Ship owner project coordinator	Seaman, chief engineer	14	9
Ship owner site manager	Seaman, captain	12	30
Ship owner superintendent	Seaman, captain	5	13
Shipyard project manager	Shipbuilding, engineer	20	n/a
Shipyard assistant project manager	Shipbuilding	6	n/a

The validity of the study has been addressed in a number of ways. First, the respondents were invited to check the collected data from the interviews. Second, the use of multiple respond-

ents from different organisations is an advantage in qualitative research. However, there are also limitations to the study. Although the research was carried out with the intention of making it replicable, it must be acknowledged that a different researcher with different participants on a different occasion may uncover different results.

ANALYSIS AND RESULTS

Analysis approach

Qualitative data refer to essences of people, objects, and situations. Empirical data collected through observations, interviews and documents, were put into issues such as phases and activities for the shipbuilding project, need for knowledge transfer, organisational mechanisms supporting knowledge transfer and barriers to knowledge transfer. The themes were culled deductively from prior theories as presented in previous sections. The data collection activities were carried out in a shipbuilding project in a sustained period of time during spring and summer 2010. According to Miles and Huberman (1994) qualitative data analysis consists of three concurrent flows of activity: data reduction, data display, and conclusion drawing and verification.

Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data that appears in written-up field notes or transcriptions (Miles and Huberman, 1994). The data reduction occurred continuously throughout the life of the case studied. Even before the data were actually collected, the researchers decided to focus on mechanisms facilitating knowledge transfer in shipbuilding projects. As data collection proceeded, further episodes of data reduction occurred (e.g. writing of summary, coding, teasing of themes). In this research qualitative data were first reduced and transformed through summary, and then analysed according to knowledge management theories, as presented in previous sections.

The second major flow of analysis activity is data display. Generically, a display is an organised, compressed assembly of information that permits conclusion drawing and action (Miles and Huberman, 1994). Table 1 indicates that both project and operational experience of sailing officers are important in shipbuilding projects. All interviewees recognised the important role of sailing officers.

The third stream of analysis activity is conclusion drawing and verification (Miles and Huberman, 1994). From the start of the data collection, the researchers were looking into knowledge transfer and sharing mechanisms and progressively into the new role of officers as project members. A final conclusion was not drawn, but findings indicated a need for further research into officers' roles.

Shipbuilding phases and activities

Five shipbuilding phases were identified as scoping, specification, negotiation, building, and acceptance testing, as shown in Table 2. Each phase had different activities and objectives, with different needs for knowledge transfer. In the shipbuilding project studied, stakeholders with different knowledge bases were involved with the purpose to create modern and high quality vessels with the functionality required for specific offshore operations. The most important stakeholders involved were the top management teams of the ship owner and shipyard and the project teams. Influential stakeholders also included such as design and ship technology companies, operators, shipbrokers, and the mortgage company.

Table 2. Knowledge based activities and objective for each phase in shipbuilding projects

Phase	Knowledge based activities	Objective
Scoping	Evaluate market outsight Identify need for capacity Overall ship design	Strategic vision
Specification	Develop drawings and calculations Specify hull, engine and ship equipment Create RFP and develop evaluation criteria	Choose the best offer
Negotiation	Negotiate terms and condition Price setting of vessel and ship technology Negotiate conditions for contractual change	Sign contract(s)
Construction	Engineering Assembly Inspections	Build ship(s)
Acceptance testing	Testing offshore Authentication	Take over ship(s)

The objective of the **scoping phase** was to develop a strategic vision for the shipbuilding project, including an overall ship design. It was important for the ship owner to have knowledge about future market outsight, the availability of ships and ship design, and future capacity needed by operators. Through discussions with operators and brokers, the need for future capacity was estimated. In further discussions with design companies, the ship owner evaluates different ship design packages and selects ship equipment and systems for use on board.

> "We need knowledge of the market, vessels in operation, and what capabilities the market will need in the future. Then we take a look at rough design features of new vessels to be built." [Ship owner project director]

In the **specification phase** the ship owner decided, through discussions with possible consulting companies and shipyards, on ship design and ship technology. Typical knowledge intensive activities were such as to develop drawings and calculations, specification of hull, engine, ship equipment and systems, and calculations of capacity. During this phase ship owner is creating a request for proposal (RFP), developing evaluation criteria, and invite external bids. The objective of this phase was to choose the best and final offer.

Having specified the new vessels, the ship owner started to negotiate a contract with the selected shipyard. The objective of the **negotiation phase** was to sign a standard form shipbuilding contract, which had references to specifications and drawings. Variation orders occurred during construction, because of market changes in the operator's specific needs. As a result, there was a difference between the vessel "as specified" in the contract and vessel "as built".

In the **construction phase,** ten AHTS vessels were built as individual standalone projects. The ship owner had a project department, led by a project director, established with the purpose of following up all new building programmes running in the company. The project organisation had a project manager, a project coordinator and three site managers, as the shipyard was building the vessels at three different sites. In addition, for each individual hull, three superintendents were appointed. The project organisation had to follow-up, through inspections, engineering and assembly conducted by the shipyard. All superintendents were sailing officers – i.e., captain, chief engineer, and marine electrician – following the project onshore for 8–10 months. When the shipyard had finished a vessel, the superintendents embarked as the vessel's sailing officers. At the shipyard, the work was organised in projects, i.e. each individual hull was built with the responsibility of one project manager with five teams responsible for steel fittings, engine/pipe, fixtures, paint/service, and electrical. In addition

there are shared functions such as planning, quality control, procurement, and technical coordination, supporting all the projects.

> "Project team is staffed with officers because of their operational experience." [Ship owner project coordinator]

In the final phase the ship owner did **acceptance testing**. When all necessary equipment was tested and corrections were accepted, authentication was obtained. Then the property rights to the vessel were transferred from shipyard to ship owner.

Need for knowledge transfer

According to Alavi and Leidner (2001), organisations have four knowledge processes: creation, storage and retrieval, transfer, and application. In Table 3, we summarise the need for knowledge transfer between ship owner, shipyard and the project organisation. The table illustrates the need for knowledge transfer internally at ship owner and shipyard, between ship owner and shipyard, and from offshore operations to project. Observations show that the need for knowledge is at the know-how level (Boh, 2007).

Table 3. Stakeholders' needs for knowledge transfer

Stakeholder	Need for knowledge transfer	Approach	Path
Ship owner	Know-how to run new shipbuilding project(s)	Pull	From one project to another
	Know-how to operate vessel(s) offshore	Push	From project to operations
Shipyard	Know-how to build modern high quality vessels	Pull	From one project to another
	Know-how to apply available ship technology	Pull	From external to project
Project	Know-how to act as superintendent	Push	From operations to project

The ship owner onshore organisation had its main focus on future application of the new vessels, but needed know-how to run the new building programme. Thus, a project team was put together with very experienced team members, as shown in Table 1, with know-how to run shipbuilding projects. Team members had previously participated in shipbuilding projects of several support vessels, multi role service vessels, and AHTS vessels. The ship owner was also making use of existing knowledge available from shipyard and ship technology suppliers in the specification phase. Thus, it is reasonable to state that the ship owner onshore organisation had a pull approach to knowledge (Davenport, 1997).

> "As regular supply-vessel operations is not a very project oriented business, we have little formal project competence in our basic organisation. To handle the new building programme of ten AHTS vessels, we have a dedicated project organisation with very experienced team members." [Ship owner HR director]

A ship owner's value creation can be characterized as based on value shop configuration (Stabell and Fjeldstad, 1998), where the primary value creation logic is solving of unique operator problems. Sailing officers had know-how to use the AHTS vessels carrying out operations such as towing and anchor handling, deepwater inspection and construction work, for the offshore industry. The project management pushed this knowledge, experience and insight into central or supportive units in the onshore organisation. Thus, it is reasonable to state that knowledge from experienced officers is pushed into the project and onshore organisation (Davenport, 1997).

> "We support our chartering department in contracting out the new AHTS vessels, because we know exactly what operations the vessels are able to handle." [Ship owner project manager]

The shipyard needed know-how to build modern high quality AHTS vessels. Shipbuilding typically follows the value chain logic where input is transformed to output during a production process (Stabell and Fjeldstad, 1998). Typical activities in the construction phase are engineering, assembly and inspections. Shipbuilding was an ongoing activity for the shipyard. By staffing their projects with experienced project managers and foremen who had knowledge gained from previous projects, they ensured improvement of existing solutions, and the development of new solutions. The shipyard also sought knowledge gained by ship technology companies, which had designed vessels for different purposes and for different clients. Typically the shipyard had a pull approach to knowledge (Davenport, 1997).

> "Through the years of building offshore supply vessels, our project teams have experienced that module-based shipbuilding raises the quality of the vessel and it reduces construction time." [Shipyard project manager]

In the construction phase the practical knowledge of seamen was first pushed into the project, as they were heavily involved as project members. Later, when superintendents became sailing officers, their insights gained in the project were pushed back to their crews (Davenport, 1997).

> "My focus is on functionality, quality and safety onboard a sailing vessel. When I see things that will not work in operations at sea, then I suggest changes." [Ship owner superintendent]

Many shipbuilding activities are based on explicit knowledge, such as contracts, drawings, specifications and calculations. They are institutionalised and transmittable in formal, systematic language (Boh, 2007). Knowledge expressed in the documents mentioned above was transferred between the different stakeholders involved in the project, e.g., ship owner, shipyard, design company, ship technology suppliers, and the ship classification company. The knowledge of what happens in operations at sea is personal, hard to formalise and hard to express (Boh, 2007). This kind of tacit knowledge was transferred through personal interactions.

Mechanisms facilitating knowledge transfer

In previous section we recognised the need for knowledge transfer as follows: 1) from one project to another, 2) from project to shipyard, and 3) from operations to project. Mechanisms facilitating knowledge transfer from one project to another or subsequent projects are, as such:

- *Cross-project staff.* Ten AHTS vessels were built at three different locations. With a minimum of 24 months building time for each vessel, and around 300,000 man-hours, some were built in parallel and some subsequently. At the time of this case study, three different vessels were under construction, i.e. BN334, BN335, and BN336. Although the series of vessels were to a large extent equal, there were variation orders for each vessel, depending on anchor handling, towing and lifting equipment. The project director, project manager and project coordinator played important roles transferring knowledge acquired between the different stakeholders from one project to another, as they participated in all projects. We will describe this knowledge exchange mechanism as institutionalised-personalisation (Boh, 2007).

- *Personnel network.* Every vessel had a formal project management team. As some vessels were built in parallel and some were subsequent, there were several simultaneous teams. These teams were co-located at the shipyard to facilitate knowledge transfer within and between teams. According to (Boh, 2007) this can be both an individu-

alised-personalisation mechanism and an institutionalised-personalisation mechanism for knowledge sharing.

- *Technical inspection.* Documents from technical inspection were an important part of quality assurance. The main focus of the inspection was functionality, quality, and safety on board. Inspection records, progress reports and photo archives were built for each vessel. Technical inspection records served as the medium for knowledge transfer between parallel and subsequent projects. This is explicit knowledge exchanged through an institutionalised-codification mechanism (Boh, 2007).

- *Common project meetings* for all concurrent vessels facilitated knowledge transfer at a collective team level. The team members were able to learn from each other, and we categorise this mechanism as institutionalised-personalised (Boh, 2007).

- *Final meeting evaluating each project.* When a vessel was delivered, involved team members held a one-day meeting evaluating functionality, costs and schedule. One important question was asked: "What can we do differently in the next project?" Since results from the meeting were documented and distributed internally we categorise this knowledge exchange mechanism as institutionalised-codification (Boh, 2007).

Mechanisms facilitating knowledge transfer from project to shipyard:

- *Owner's meeting.* During the building of a new vessel, the ship owner and shipyard met every third or fourth week following up progress of the project. The most important issue was to agree upon variation orders, as changes influenced specifications and drawings, as well as costs and schedule. Participants were project management from both ship owner and shipyard. This was a formal meeting representing structured knowledge sharing at a collective level, and we categorise the mechanism as institutionalised-personalisation (Boh, 2007).

- *Production meeting with deviation list.* Every week the shipyard held a production meeting for each vessel, reporting on progress and deviations. A deviation list was prepared by the ship owner site manager and followed up by the shipyard assistant project manager. Disagreement was escalated to the owner's meeting. The list served as explicit knowledge transfer as it focused on inspections, deviations and authentications, suggestions/solutions, and comments for each item on the list. We describe the mechanism as institutionalised-codification (Boh, 2007).

- *Informal inspections* were carried out on a one-to-one relationship between superintendents and foremen. Small issues, e.g. location of a valve or steel execution, were carried out on site without involving others, as they did not influence costs and schedule. Larger issues, e.g. change of drainage or ventilation, were more complicated, and caused extra work, costs, and changes in design and specifications. These changes were escalated to the production meeting and/or to the owner's meeting. Superintendents met supplier site teams lead by foremen on a day-to-day basis. This is application and transfer of tacit knowledge and we categorise this mechanism as individualised-personalisation (Boh, 2007).

- *Project office located at shipyard.* The ship owner project management team was located at the shipyard. This enabled both formal and informal communication and information sharing with the shipyard. In addition, the location also served as a meeting place for team members with different experience; thus facilitating knowledge transfer within the team. This knowledge transfer and sharing mechanism is in line with what

Boh (2007) defines as a support centre and can be categorised as institutionalised-personalisation.

- *Revision of drawings and calculations.* Due to construction deviations, variation orders, formal and informal inspections, there were revisions of drawings and calculations. All changes to a vessel during construction can be transferred through revised documents to the next project. In Boh's (2007) terminology, this mechanism can be categorised as institutionalised-codification.

Mechanisms facilitating knowledge transfer from operations to project:

- *Job-rotation.* Experienced officers such as captains, chief engineers, and maritime electricians were appointed to the project team as superintendents, bringing real world operational experience from anchor handling, towing and deep-water inspections, into the project. The superintendents followed the shipbuilding process for 8-10 months, and when the vessel was taken over they signed on as sailing officers. By this process, new technology was refined and customised for the purpose of the vessel. Part of this knowledge was made explicit in terms of revisions of contracts, specifications, drawing, variation orders, reports and deviation lists. We describe this knowledge transfer and sharing mechanism as institutionalised-codification because it captures individual knowledge and makes it the wider property of the project and organisation. However, knowledge transferred was also tacit in terms of experienced officers' situation-specific knowledge. This is an institutionalised-personalisation mechanism in which the knowledge is shared based on direct interactions between individuals (Boh, 2007).

- *Template of best practice.* As the ship owner was building a series of ten vessels, former superintendents were later recalled to the project office to report their experience with ship equipment such as engines, pumps, manometers, and valves. In this way, the ship owner was able to improve every new vessel, based on experience earned by sailing officers. As stated by ship owner site manager: "Eventually, a template of very high quality has taken form, which we call the company standard." The template was a form of explicit knowledge transfer, and can be categorised as an institutionalised-codification mechanism (Boh, 2007).

- *Captain's review.* On a yearly basis, the captain of a vessel had the responsibility to report: 1) accident(s) or near accident(s), 2) non-conformity (i.e. deviation from specifications), and 3) suggestions for improvement. The captain's review made it possible to transfer experience from operations into the next project. We categorise this as an individualised-codification mechanism (Boh, 2007).

- *Learning-by-doing.* A bridge-team training programme was partly simulator based training, and partly learning-by-doing anchor handling assisted by an experienced officer. This was word of mouth knowledge sharing through senior staff, which can be categorised as individualised-personalisation (Boh, 2007).

A summary of knowledge transfer and sharing mechanisms identified in the new building programme of ten AHTS vessels are listed in Table 4.

Table 4. Knowledge transfer and sharing mechanisms

Main paths of	Knowledge transfer and sharing mechanisms

knowledge transfer	Individualised-personalisation	Individualised-codification	Institutionalised-personalisation	Institutionalised-codification
From project to another project	• Personal network	• Project evaluation meeting	• Cross-project staff • Common project meetings	• Technical inspection
From project to shipyard	• Informal inspections	• Production meeting with deviation list	• Owner's meeting • Project office located at shipyard	• Revision of drawings and calculations
From operations to project	• Learning-by-doing	• Captain's review	• Job-rotation	• Template of best practice

CONCLUSIONS AND RECOMMENDATIONS

In this study, five shipbuilding phases were identified as scoping, specification, negotiation, construction, and acceptance testing. Stakeholders interviewed emphasised the need for knowledge transfer between ship owner, shipyard and shipbuilding project, especially in the construction phase. In the case studied, ten advanced anchor handling tug supply vessels were built with a stable design, within costs and delivered on schedule. Knowledge transfer was at the know-how level, indicating that: 1) the ship owner needed know-how to run the shipbuilding process and to operate vessels at sea, 2) the shipyard needed know-how to build modern high quality vessels and to apply available ship technology, and 3) the shipbuilding project needed know-how to act as superintendent.

Mechanisms facilitating knowledge transfer between operations and project were learning-by-doing, captain's review, job-rotation, and template of best practice. Mechanisms facilitating knowledge transfer from project to shipyard were informal inspection, production meeting with deviation list, owner's meeting and revision of drawings and calculations. Last but not least, we found mechanisms facilitating knowledge transfer from one project to another, such as: personal network, evaluation meeting, cross-project staff, and technical inspection.

One important success factor was the use of experienced officers in the project organisation. They push their knowledge, experience and insight from regular supply, towing and anchor handling, deepwater inspection, construction work, into the project. In every activity carried out in the ship building process, their focus was to build high quality vessels for global offshore operations. As they finished their job in the project and again became sailing officers, they secured knowledge transfer from project to operations at sea. Using experienced officers as project team members, the ship owner was able to build vessels of high quality and reinvent fewer wheels.

Other researchers should examine the findings through more rigorous research design. As this research was conducted in one shipbuilding organization, studies can be conducted among shipbuilding organizations in different countries, or even within the same country, but with other organisations involved. Future research should also consider data collection from various sources, e.g., observations in meetings and inspections, and even document studies of drawings, calculations and deviation lists. Future studies can also identify additional mechanisms and examine more thoroughly the transfer of knowledge acquired between different stakeholders and the firms.

Although the context, pattern of results, and method limit the extent to which generalisations can be drawn from this research, some tentative managerial recommendations should be acknowledged. First, we argue that the dominance of tacit knowledge in projects is a key challenge, e.g. the use of sailing officers. As an answer to this situation we recommend the development of an organisational culture supporting knowledge transfer and sharing. For ex-

ample, we suggest that the line organisation and senior managers should be more visible when it comes to supporting knowledge transfer between projects. Second, we also suggest that the firm should establish knowledge transfer routines. It is about putting knowledge transfer on a project's agenda. Let knowledge transfer be incorporated in the project process from the beginning and keep it in focus throughout the project development. Finally, the firms should support inter-project knowledge transfer by arranging meetings, courses, workshops and seminars.

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