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AN ACTIVITY THEORY ANALYSIS TO KNOWLEDGE SHARING FROM TENDER PHASE TO ENGINEERING PHASE IN D&B PROJECT TEAMS

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PREFACE

This research paper is written as final part of the master Construction Management and Engineering at the University of Twente, the Netherlands. This research has been conducted commissioned by Dura Vermeer Bouw Hengelo BV and focuses on the problems and improvement regarding the internal transition process from tendering to engineering in industrial D&B UAC-IC projects.

Although the graduation process is mainly an individual activity, I would like to thank the following people for their time and effort.

First, I would like to thank my supervisors from the University of Twente, dr. ir. Robin de Graaf and drs. ing. Hans Boes, for their guidance and their critical, but valuable criticism that kept me sharp during the process and brought me new insights.

Further, I would like to thank ir. Tine-Loes Hemmes who guided me on behalf of Dura Vermeer Bouw Hengelo BV. With her I had inspiring meetings that brought me to new, sharpened insights regarding not only to the research, but also to my future possibilities on the labor market. Thanks to her, I pushed my limits.

Finally, I would like to thank my family and friends, and in particular my sister, Jolien, who supported me not only personally but also professionally because of the critical view she glanced at my research. Thanks to them I look back proudly on my study career and I look with great enthusiasm forward to new challenges!

Sophie Roesthuis.

Denekamp, June 2018

University of Twente & Dura Vermeer Bouw Hengelo BV

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PAPER

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An Activity Theory analysis to knowledge sharing from tender phase to engineering phase in D&B project teams

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ABSTRACT: In construction firms, the transition from tender phase to engineering phase in the project life cycle is often problematic. During such a transition, knowledge has to be shared from the project team in the tender phase to the project team in the engineering phase. This study focuses on that knowledge sharing from tender phase to engineering phase in D&B project teams and took place at a construction company located in the Netherlands. The main research question is how the transition from tender phase to engineering phase in D&B UAC-IC complex industrial projects can be improved. Interviews with team members of the project team were the primary data source in this study. The Activity Theory is used as qualitative analytical framework. The findings indicate that there are deviating and lacking roles in the project team and that due to using different tools, knowledge sharing is being impeded. To improve the knowledge sharing process, the project team needs to learn by expansion: from sharing information through a project dependent approach to a standardized approach, and from multiple tools to a standardized document management tool that has to be examined by the project team.

Key words: project teams, Activity Theory, knowledge sharing, contradictions, expansive learning

1 INTRODUCTION

Nowadays construction firms embrace the project-based organization form to improve the project delivery efficiency, since they are being faced with increasingly complex demand and strong market competition (Buvik & Rolfsen, 2015; Zhao, Tang, Zhang, & Skitmore, 2017). ‘The use of the Design & Build (D&B) project delivery system has increased since the introduction of the Uniform Administrative Conditions for Integrated Contracts 2005, partly at the expense of the Design-Bid-Build project delivery system’ (Cheung, 2015, p. 2). Delivering D&B projects, which has become construction company’s core business, requires the integration of multidisciplinary expertise in multidisciplinary project teams (Buvik & Rolfsen, 2015; Fong & Kwok, 2009). Integrated tenders aim to achieve close collaboration and communication among all members of a project team (Eastman, Techolz, Sacks, & Liston, 2011) and has a need for better integration and coordination (Maunula, Riitta, & Hirvensalo, 2008). The complexity of such tenders is caused by the following. First, there is a large amount of data that needs to be processed in a very short period of time. Second, there is a transition from tender specifications to integral design which requires new competences from the project team members. Third, there is a risk in not covering all client specifications since information is translated into a design in a short period of time with high work pressure. Collaborative interaction is required to take advantage of the functional diversity of a multidisciplinary project team (Daspit, Justice Tillman, Boyd, & McKee, 2013; Male, Bower, & Aritua, 2007). Hence, according to Buvik and Rolfsen (2015), executing a project successfully relies on the ability of the project team of integrating the relevant knowledge and skills that are distributed among its team members and across teams. A stable and bounded project team that strengthens the group cohesion stimulates this integration of knowledge and skills, and enhances the knowledge sharing process (Eisele, 2013; Huang, 2009).

The construction industry is a project-based industry, temporary project teams are responsible for the project activities (Solli-Saether, Karlsen, & van Oorschot, 2015; Zhang & Cheng, 2015). These project teams can be characterized as knowledge intensive teams, they involve a wide range of team members who have different expertise backgrounds and possess specialized an distributed knowledge (Ding, Ng, & Cai, 2007). Transforming from the tender activities to the engineering activities and subsequently to the building activities in the project life cycle, information has to be shared to the other team members. Data, unprocessed raw facts, and information, meaningful aggregations of data, together forms the concept of 'knowledge' (Ajmal & Koskinen, 2008). Hence, knowledge needs to be shared between project team members. To increase project performance, knowledge sharing is a precondition (Ding, Ng, & Li, 2014). The knowledge sharing process involves interpersonal relationships and social interactions (Lin, Wu, & Lu, 2012) and it requires collaboration, including cooperation, a common goal or trust among designers to contribute and exchange their individual knowledge, which is appropriate and relevant to engineering design problems (Lin et al., 2012; Yang, Dong, & Helander, 2012). A successful project team starts with goal alignment and is being able to share knowledge, which enhances the team effectiveness (Ramim & Lichvar, 2013; Snippert, Witteveen, Boes, & Voordijk, 2015; Wang & Wang, 2012).

The goal of the study is clarifying the problem experienced by the project team members during the transition from tender phase to engineering phase in D&B projects and providing possible solutions to improve this transition. The transition is the moment the project knowledge is being shared from the project team in the tender phase to the project team in the engineering phase. The project team seems not successful because there is no good project performance, the projects are less profitable, the roles of the team members are not clear and knowledge is not being shared. The consequences the construction company experiences are repeated mistakes, double work, lack of innovation and organizational inefficiency. The construction company aims for a successful project team that is being able to share knowledge.

Knowledge sharing is a core capability essential for team integration (Wen & Qiang, 2016), since it acts as the basis of integrating multidisciplinary expertise and it is important for improving project performance and successful project delivery (Javernick-Will, 2011; Zhang & Ng, 2013). Furthermore, knowledge sharing enables organisational learning (Almeida & Soares, 2014; Hong, Suh, & Koo, 2011; Nidumolu, Subramani, & Aldirch, 2001; Rezgui, Hopfe, & Vorakulpipat, 2010), and encourages the project team members to follow best practices and avoid the repetition of mistakes in subsequent projects (Reich, Gemino, & Sauer, 2014). Besides that, continuous improvement in project performance will be facilitated if knowledge is being shared throughout the teams (Fong & Kwok, 2009; Kale, 2011). Knowledge sharing forms the basis for communication and coordination of multidisciplinary project teams (Wen & Qiang, 2016). One theory relevant for studying complex developments in organizations is the Activity Theory. The Activity Theory provides a model that has been introduced as the activity system and has been used extensively to map existing and future organizational practices (Akkerman, 2012). It provides a framework for analysing the knowledge sharing process of multidisciplinary project teams on project level, inspired on Engeström (2000); Yamagata-Lynch and Haudenschild (2009); Zahedi, Tessier, and Hawey (2017).

The Activity Theory is explained in the next section, by describing its fundamentals and how the theory is being used as analysis method. Section 3 describes the research methodology. In section 4 the findings are presented according to the Activity System analysis. Subsequently, the conclusion is provided in section 5, followed by the recommendations in section 6. Section 7 describes the implementation of the recommendations in practice. The paper concludes with the limitations and possibilities for future research, described in section 8.

2 ACTIVITY THEORY

The Activity Theory, which originated from the ideas of Russian psychologist Vygotsky (1978), investigates collectively mediated behaviour that is aimed at an outcome by taking activities as its analysis units instead of individual actions (Boer, van Baalen, & Kumar, 2002). Engeström (1987) elaborates on the concept of Vygotsky (1978) by providing a model for describing and analysing activities. The Activity Theory is a generic multidisciplinary research approach (Chaiklin, Hedegaard, & Jensen, 1999; Engeström, Miettinen, & Punamäki, 1998; Zahedi et al., 2017), which is increasingly focusing on the study of work and technologies, the challenges and possibilities of inter organizational learning (Engeström, 2000, 2001; Yamagata-Lynch, 2003) and can be applied to represent organizational change (Barab, Schatz, & Scheckler, 2004; Engeström, 1993) to identify contradictions and tensions that shape developments

(Barab, Barnet, Yamagata-Lynch, Squire, & Keating, 2002).
The Activity Theory offers researchers and practitioners a holistic interpretation of a real-world situation that is comprehensive and clear. It gives managers deeper understandings into what is happening in their business over time as perceived by different stakeholders such as employees, clients and customers (Hasan & Kazlauskas, 2014). The Activity Theory provides a comprehensive understanding of how people collaborate, i.e. carry out purposeful collective activities, with the assistance of sophisticated tools in the complex dynamic environments of modern organizations (Hasan, 1999; Waycott, Jones, & Scanlon, 2005). The Activity Theory is grounded in almost a century of research and has a rich tradition applied to many fields of study (Hasan & Kazlauskas, 2014). The Activity Theory is becoming more and more relevant because learning and doing are increasingly coinciding. It is no longer learning and then doing but learning by doing. This is caused by a world becoming more and more complex and nobody knows exactly what to learn.

2.1 The fundamentals

The elements of the activity system include a subject, the tools, an object, the rules, the community, the division of labor and the outcome (Fig. 1). Each element represents specific, transactional aspects of human activity (Yamagata-Lynch & Haudenschild, 2009, p. 508). For each element, examples have been given based on the activity system identified by Fujioka (2014) in her research to student and professor interactions. The subject of the activity system is the individual or group whose viewpoint is chosen in the analysis (Boer et al., 2002; Plakitsi, 2013), and is the participant in the activity motivated toward a purpose or attainment of the object. However, subjects are not limited to individual humans, other types of entities, such as animals, teams, and organizations can also be subjects of activities (Kaptelinin & Nardi, 2012). For example, a student or group of students. The object can be the goal of the activity, the subject's motives for participating in an activity, and the raw material or problem space at which the activity is directed and which is transformed into outcomes with the help of tools (Engeström, 1993; Yamagata-Lynch & Haudenschild, 2009), it precedes and motivates the activity. For example, writing a research paper. Tools are socially shared cognitive and/or material resources that subjects use to achieve the object. For example, class readings, discussions, and a model research paper. The rules are explicit and implicit norms and regulations that regulate actions and interactions of the subject's participation while engaging in an activity (Boer et al., 2002; Plakitsi, 2013; Yamagata-Lynch & Haudenschild, 2009). For example, academic writing conventions and instructional guidelines. The community refers to the group or organization to which subjects belong. The community of the illustrated example is identified as the classroom community. The division of labor refers to both the horizontal division of tasks and roles among the actors involved and the vertical division of power and status (Boer et al., 2002; Van Vlaenderen, 2001). For example, student completing the paper. Finally, the outcome are the consequences the subject faces because of his/her actions driven by the object. These outcomes can encourage or hinder the subject's participation in future activities (Yamagata-Lynch & Haudenschild, 2009, p. 508). Regarding the illustrated example, the outcome is the increased understanding of the research topic.

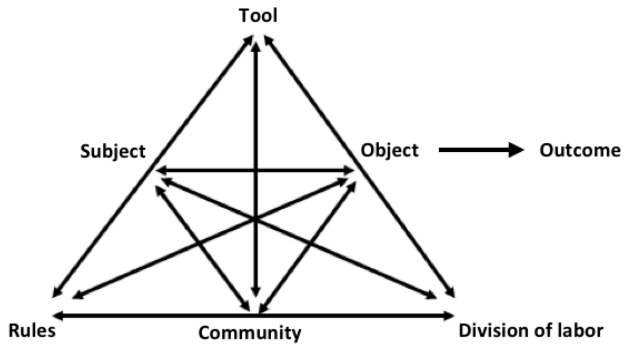

Fig. 1: The basic schematic of an activity system as developed by Engeström (1987)

2.2 Using the theory

The activity system model has been employed in a range of disciplines, such as the instructional and performance technology (Barab, Evans, & Baek, 2003), but also in the educational and organizational learning (Barab et al., 2003; Kaptelinin & Nardi, 2012). The focus of this study is on the knowledge sharing process between tender team and engineering team, part of the project life cycle of industrial D&B projects in a Dutch construction company. The Activity Theory is relevant in this study because it focuses on the inter-organizational learning of internal project processes that takes place in the project management area within the construction industry. It analyses relationships between practical activity and the organisational context and cannot be separated from the environment in which it takes place. By analysing the relations of the knowledge sharing process throughout teams, expansive learning is pursued. 'That is, learning in which the learners are involved in constructing and implementing a radically new, wider and more complex object and concept for their activity' (Engeström & Sannino, 2010, p. 2). Expansive learning is relevant since an improved outcome is intended together, which is impossible when stick to the old situation. The transition from tendering to engineering is identified as the activity, according to the definition: 'an activity is a coherent, stable, relatively long-term endeavour directed to an articulated or identifiable goal or object' (Barab et al., 2003; Rochelle, 1998). Where activities are composed of goal directed actions that must be undertaken to fulfil the object (Barab et al., 2003). However, if an activity deviates from the 'standard', it shows disturbances (Engeström, 2000). Those disturbances indicate developmentally significant fundamental contradictions and potentials for change and improvement within the activity.

Identifying the contradictions in the activity system aims focusing on the efforts on the root causes of problems, which supports the first part of the research goal of this study. Further, an Activity Theory analysis is a crucial precondition for the creation of a shared vision for the expansive solution of the contradictions (Engeström, 2000). It might provide a solution to the research problem, which supports the second part of the research goal. The importance of contradictions is that they serve as indications of both discordance and, more positively, potential opportunities for intervention and improvement. Hence, contradictions should not be mistaken as dysfunctions, but as functions of a growing and expanding activity system (Barab et al., 2003, p. 208). This is where the theory of expansive learning comes in. The inner contradictions offer possibilities for expansive developmental transformations. Such transformations proceed through stepwise cycles of expansive learning which being with actions of questioning the existing standard practice (1), then proceed to actions of analysing its contradictions (2) and modelling a vision for its zone of proximal development (3), then to actions of examining (4) and implementing the new model in practice (5) (Engeström, 2000, p. 960).
The theory of expansive learning focuses on learning processes in which the very subject of learning is transformed from isolated individuals to collectives and networks (Engeström & Sannino, 2010, p. 5). Learners learn something that is not yet there: the learnings construct a new object and concept for their collective activity and implement this new object and concept in practice (Engeström & Sannino, 2010, p. 2).
According to Engeström and Sannino (2010) the unit of analysis in expansive learning are two or more activity systems that have a partially shared object.

> "The contradictions are the necessary but not sufficient engine of expansive learning in an activity system. Conflicts, dilemmas, disturbances and local innovations may be analysed as expressions of the contradictions. … Contradictions become actual driving forces of expansive learning when they are threated in such a way that an emerging new object is identified and turned into a motive. … Expansive learning leads to the formation of a new, expanded object and pattern of activity focused on the object. … The process of expansive learning must be understood as the construction and solution of consecutively evolving contradictions." (Engeström & Sannino, 2010, p. 7).

In other words, the cycle of expansive learning should be traversed to resolve the contradictions emerging within and between the activity system and eventually the knowledge sharing process throughout the teams can be improved.

2.3 Activity System analysis

The Activity Theory can be employed for analysis and design in three generations, based on the distinction made by Engeström (1996, 2001) and elaborated by Barab et al. (2003, pp. 207-208). The first generation includes using the activity theory as a lens, map or orienting device to structure the analysis of complex sociocultural learning and performance contexts (Barab et al., 2003), inspired on Vygotsky's mediated action triangle (Yamagata-Lynch & Haudenschild, 2009).
The second generation elaborates on the first generation and aims at structuring the activity hierarchically by discovering and constructing the motives of the overall activity system, the needs associated with the actions of individual participants and users, and the conditions that enable inhibit accompanying operations (Barab et al., 2003; Leontiev, 1978).

Finally, the third generation of the activity theory elaborates on the second generation and is about identifying the contradictions within and between the components of the activity system as well as across entire activity systems that have a shared object (Barab et al., 2003; Engeström & Sannino, 2010; Yamagata-Lynch & Haudenschild, 2009).
This research focuses on the third generation Activity Theory as developed by Engeström (1996, 2001) by increasing the analytical scope of activity systems analysis. In third generation activity theory, the minimum unit of analysis is joint activities (Fig. 2). Joint activities require two activity systems that are intertwined. This analysis method tries to understand the interactions between joint activities and their outcomes in order to resolve contradictions caused by joint activities (Yamagata-Lynch & Haudenschild, 2009).
Fig. 2 shows two interacting activity systems initiated by different subjects (subject 1 and subject 2). The two activities are linked to the shared object (object 3) in the two activities. "The relationship between the two activities can trigger a chain reaction of mediated actions within the individual activities. These chain reactions from the joint activities can lead to inner contradictions for the individual activity and the joint activity." (Yamagata-Lynch & Haudenschild, 2009, p. 509)

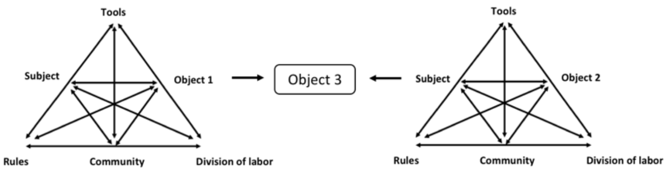

Fig. 2: Interacting activity systems in third generation activity theory adapted from Engeström (1996)

In this research, third generation activity theory by using activity system analysis is used as tool to study the intersection of activities shared between the tender team and the engineering team. It provides a comprehensive and insightful method to provide a rich description of the situation (i.e. the transition). Further, it enables research to represent and explain the changes that are identified during the case study in complex environments and gives the managers deeper understandings into what is happening in their business (Hasan & Kazlauskas, 2014, p. 12).

2.3.a Four levels of inner contradictions

Engeström (1987) presented four levels of contradictions that should be attended in analysing a learning or work situation (i.e. the activity). Based on literature (Barab et al., 2003; Hasan & Kazlauskas, 2014; Kaptelinin & Nardi, 2012; Yamagata-Lynch & Haudenschild, 2009) each contradiction is explained.
Primary contradictions (level 1) arise *within* each node of the central activity that's being researched, e.g. shortcoming of the tools used.
Secondary contradictions (level 2) arise *between* components of the central activity system. They occur when activity participants encounter a new aspect of an activity, and the process for assimilating this new aspect into their daily activity brings about conflict, e.g. issues of usability between the user (subject) and the tool.
Tertiary contradictions (level 3) arise *between* the object of the central activity and the object of a culturally more advanced form of the central activity and occur when activity participants face adverse situations by adopting what is believed to be a newly advanced method for achieving the object. For example, if new tools automate operations of an activity, humans may no longer be needed to do those operations, e.g. driverless trains.
Quaternary contradictions (level 4) arise *between* the central activity and adjacent activities. It refers to the contradictions within a network of activity systems, that is, between an activity system and other activity systems involved in the production of a joint outcome. Those contradictions occur when activity participants encounter changes to their activity that result in conflict with adjacent activities, e.g. misunderstandings between the teaching of the teacher and the learning of the learner.
Those four levels of inner contradictions form the four sources of tensions within the activity system (Hasan & Kazlauskas, 2014), schematically presented in Fig. 3.

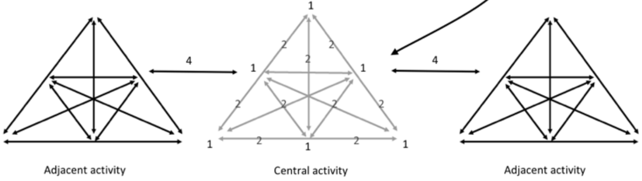

Fig. 3: Four levels of contradictions in a network of activity systems (Engeström, 1999)

3 METHODOLOGY

The research is a case study research inspired on Eisenhardt's (1989) method. Engeström's (1987) model is used to organize the findings from this case study research into activity system units, and map out the sources of systemic tensions involved in those activities. Through this analysis it was intended to identify the problems the teams encounter during the transition when knowledge has to be shared, which contributes to the first part of the research goal: 'Clarifying the problem of a distorted transition by identifying the causes'. The activity system is mainly used as a descriptive tool for identifying and modelling the complexities experienced by a transition in single activity system units. Thereafter, the single activity systems were analysed on their joint activities affecting the individual knowledge sharing activities. Finally, the contradictions within and between those systems are being analysed by the expansive learning cycle in order to resolve the contradictions causing disturbances, contributing to the second part of the research goal: 'providing possible solutions to improve the transition from tender phase to the engineering phase in D&B UAC-IC complex industrial projects'. The specific research questions that were addressed were (1) How is *knowledge sharing* between tender team and engineering team currently organised? (2) What *contradictions* occur within and between the knowledge sharing activities? (3) How can *expansive learning* be pursued regarding the knowledge sharing process?

3.1 Research participants

This study took place within a Dutch construction company which belongs to the top 10 largest construction companies in the Netherlands. The company has a size of approximately 2,500 employees and is active in the construction, infrastructure, engineering and service industry, oriented nationally.

Team members from two particular teams, the tender team and the engineering team, were interviewed since those teams considered problems during the knowledge sharing process. In total two cases are being researched, whereof all the team members are being interviewed.

The first case included a D&B project with UAC-IC specifications. It was a phased project with a capped budget and the building is a residential-care complex for disabled people. In total eleven team members were involved in this project from tender phase to engineering phase. The second case is an industrial project with a DBM contract, with a UAC-IC structure. It is a residential care complex, that involves demolition work and the construction of new buildings. It is a phased project, since among other things the users are very sensitive and the process contains movements of the users.

3.2 Data collection

Multiple data collection methods are used to collect the data: interviews and desk research. By using multiple data collection methods, triangulation is pursued and enhances the internal validity and reliability of the data collected (Devers, 1999; UvA, 2002). Interviews are the primary data source and were formatted based on the components of the activity system. Desk research provides the secondary data source, including project management plans, process schemes, and time lines. These data sets provide background information regarding the transition process. An overview of all sources is presented in Table 1.

Table 1: Sources of data collection

Case I		**Case II**	
Interviews	*Desk research*	*Interviews*	*Desk research*
Director Preparation Project manager Preparation Cost engineer Two Project managers C&M Member of the Planning office Project manager Maintenance and Renovation Project leader BIM Engineer Technical engineer UAC-IC engineer	Project Management Plan, June 2017 Project Management Plan, July 2017 Process scheme, May 2017 Plan of Action, August 2016	Project manager C&M Project manager Preparation Cost engineer Member of the Planning office Project leader Director Preparation Technical engineer BIM modeller Site manager	Agenda of kick off meetings, April and June 2016 Plan of Action, November 2016

3.3 Data analysis

The Activity Theory can be used as a multi-layered analytical framework for studying complex situations such as interdisciplinary collaboration in design projects (Zahedi et al., 2017).
The interviews are being transcribed and were coded according to the components of the activity system. The codes were structured resulting in overarching themes relevant to the research questions. The contextual level of analysis started on individual level because each team member was interviewed individually. The results of all those activity systems were identified and collected to a higher contextual level: the team level (Fig. 4). Finally, the identified components on team level were compared to the coding and thematic findings on individual level to ensure those were consistent throughout.
In correspondence to the research questions, the activity system analysis for two systems consisted of four crucial steps, inspired on Engeström (2000); Engeström and Sannino (2010); Yamagata-Lynch and Haudenschild (2009); Zahedi et al. (2017). The first step is identifying the activities that influence the knowledge sharing processes throughout teams. By executing this first step, the current situation about how the knowledge sharing is organized can be identified and provides the answer to the first research question. The second step is the identification of the shared object. The second step is necessary in order to identify the contradictions, because two activity systems are juxtaposed. The third step includes identifying and clarifying those contradictions on each level. By executing this third step, the second research question can be answered. Finally, the cycle of expansive learning has been analysed for the activities in order to resolve the contradictions. By executing the fourth and last step, the third research question can be answered.
A cross-case analysis has been done after each case has been analysed individually according to the aforementioned four steps and shows similarities and differences between both cases providing input for possible improvement.

4 ACTIVITY SYSTEM ANALYSIS

This section describes the research results derived from the case study. In total two cases are being researched. The activity system analysis resulted in two activity systems that describes the current situation and shows the contradictions that arise within and between the knowledge sharing activities. Each case contains two activity systems that have a shared object. The four steps of the activity system analysis are detailed below, distinguished by case I and II. At the end of the section, the findings of the cross-case analysis are described.

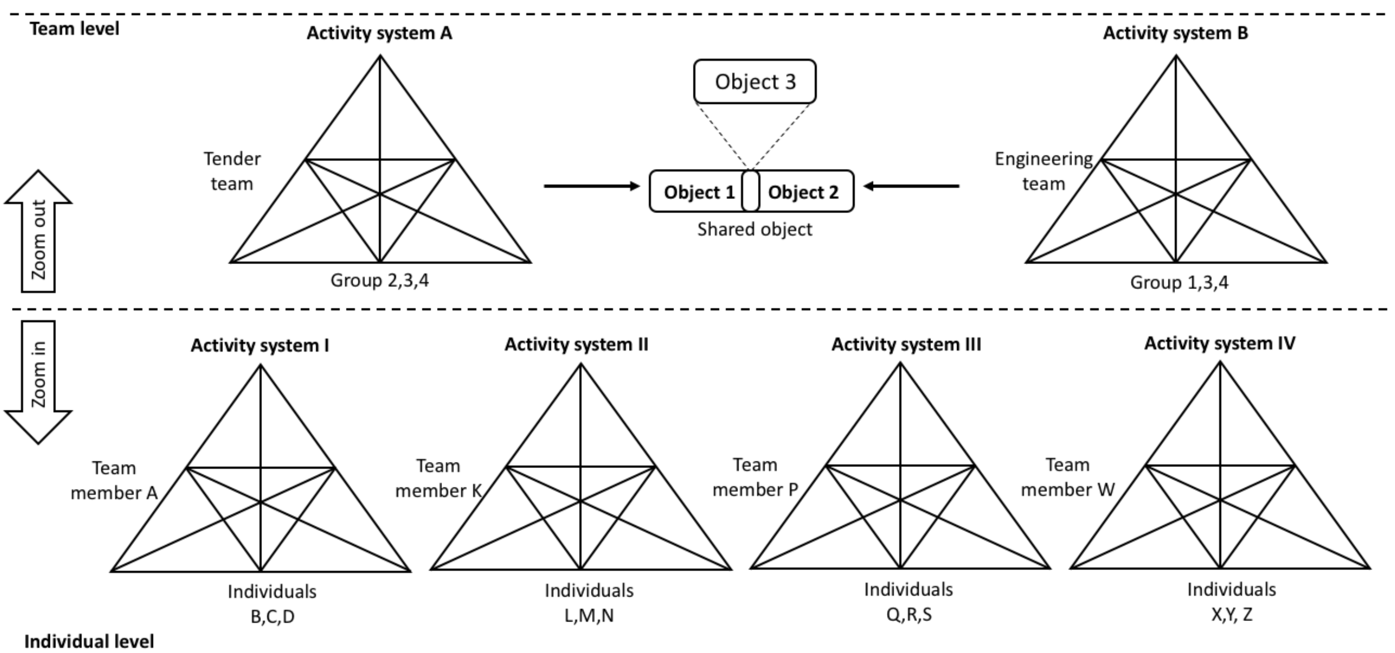

Fig. 4: Levels of activity system analysis (inspired on Boer et al. (2002) and Yamagata-Lynch and Haudenschild (2009)

4.1 Case I

4.1.a Identifying activities that influence knowledge sharing processes throughout teams

The first step of the activity system analysis is identifying the activities that influence the knowledge sharing process. The activities in case I consisted of one initiated by the tender team as subject and another initiated by the engineering team as subject. Fig. 5 and Fig. 6 illustrate the graphic summary of these activities based on Engeström's (1987) model.

In Fig. 5, the subject is the tender team who has the following objects: transferring information with little knowledge loss and having the client demands clear. The tools used to attain these objects are OneNote, Email, V-disk and a meeting. The rules describe the preconditions under which information can be transferred, such as the files need to be completely finalised and all team members need to be present, having attention for the client. The community the tender team is part of is the project team, but it also cooperates with the departments customer & market, calculation and BIM and is located at the tender department. The main task of the tender team is finalizing the files so those can be transferred to the next team.

The outcome included little to no design and financial risks and the engineering team continues independently.

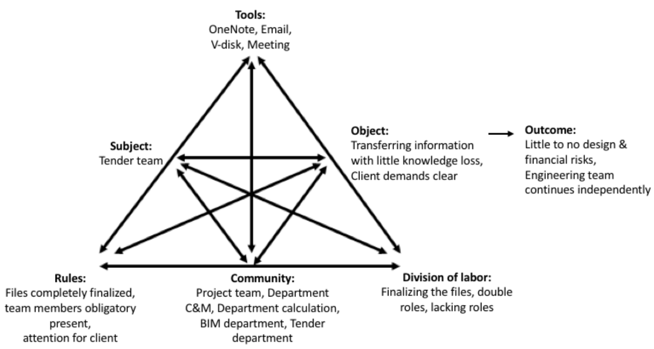

Fig. 5: The tender team activity system I

The subject in Fig. 6 is the engineering team that aims for receiving project information and getting the scope of the project clear, so they can take over the project and make it a profitable one. The tools used to achieve the object are a hard copy folder of the project, Email, Doc-stream and a meeting. The rules that apply to receive information and take over the project are determining the relevance of information for each team member and having a structured folder structure. The engineering team is part of the project team and cooperates with the departments calculation, BIM and engineering. The main task of the engineering team is reading the project information, in order to get the scope clear and take over the project.

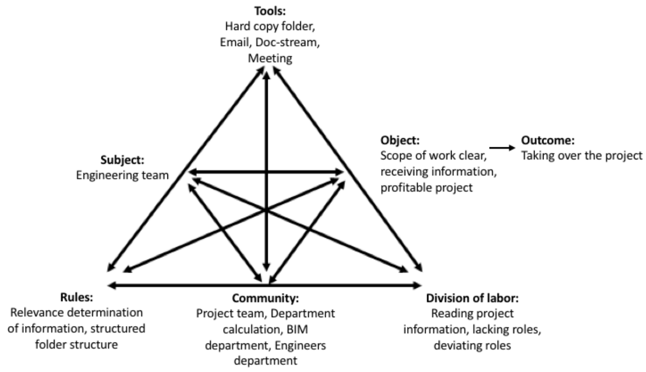

Fig. 6: The engineering team activity system I

4.1.b Identifying the shared object

The second step of the activity system analysis is to identify the shared object of both activity systems. Fig. 7 shows the activity system of the tender team from Fig. 5 and the engineering team's activity system from Fig. 6. Object 1 in this figure is the tender team object from Fig. 5 and Object 2 is the engineering team object from Fig. 6. The intersection of Object 1 and Object 2 represents the shared object. The tender team wants to transfer their project information, whereas the engineering team wants to receive the project information. Thus, the shared object is sharing project information. In the activity system analysis, it appeared that a joint activity does not guarantee that the efforts for meeting the shared object are organized and coordinated. For example, this was very clear when the engineering team wanted to take over the project but the project information was not structured at all at the V-disk, and determination of relevance became impossible for the engineering team. While the tender team found that they organised and structured the information clearly in the appropriate folders at the V-disk. The engineering team, therefore, found the V-disk a defective tool to share information with. As illustrated in this example, the uncoordinated efforts for achieving the shared object brought contradictions that affected the information sharing process throughout the teams. Those contradictions are being identified by executing the third crucial step of the activity system analysis and are described in the next section.

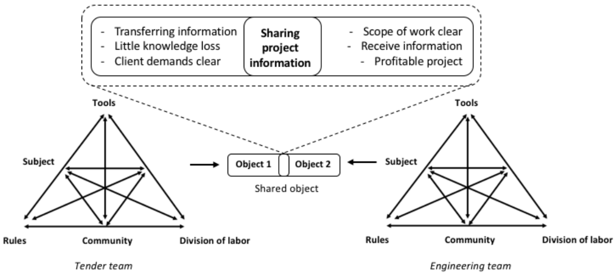

Fig. 7: Joint activities I

4.1.c Disturbances and contradictions

Accordingly, the third step is identifying the contradictions that lead to disturbances and are represented by two-headed lightning shaped arrows in Fig. 8. The first contradictions are between the object and tools. For the tender team OneNote and the V-disk are the officially accepted tools to share and store project knowledge internally. Although, the E-mail is also an often-used tool to share information among the team members and the meeting is the officially accepted tool to share the project information with the engineering team. The problem with using four different tools is that the project information is not centrally stored (1) and makes it complex to transfer the project information to the next team with little knowledge loss and keeping the client demands clear, resulting in the first contradiction (a). The second contradiction arises between the rules and division of labor via community (b). It is obligatory to have all team members present at the moment the project knowledge is being transferred to the next team. However, there are lacking and double roles within the tender team: the director preparation and project manager preparation both operated as tender manager and the project manager customer and market was lacking. The community was not complete and it was therefore impossible to have all team members present. The division of labor is distorted by those lacking and double roles (2). Hence, team members who possess important project knowledge are missing and hampered the object of transferring information, resulting in the third contradiction (c).

The first contradiction arising within the activity system of the engineering team is between the rules and the tools via the subject (d). The rules emphasize that the engineering team has to have a structured folder structure, but four different tools makes it hardly possible to do so because all project information is stored on different storage media (3). The second contradiction is between the object and division of labor (e). The project leader is missing although he is needed to take over the project. Resulting in lacking roles during the activity (4). Between the object and tools, the third contradiction arise: receiving project information via four different channels makes is hard to get the scope of work clear (f).

The two activity systems are intertwined in that they must act together to share project information: yet their objects are different and there is increasing tension between them. The first arise between the tools (A), the tender team uses the V-disk to store and share their project information whereas the engineering team uses Doc-stream to share and store their project information. Further, the tender team has a client-oriented object, i.e. client demands clear, and the engineering team aims for a technical-commercial object, i.e. a profitable project (B). Regarding the division of labor (C), the project manager customer & market joined the engineering team but she never joined the tender team although this is her team to operate within.

This deteriorating situation can be changed by means of an expansive learning process in which the two parties together generate a new shared object and concept for their shared activity (Engeström & Sannino, 2010, p. 6).

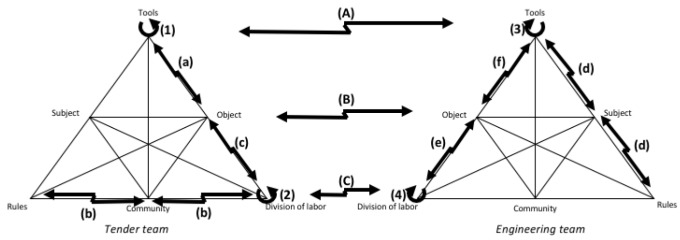

Fig. 8: The contradictions within and between the two activity systems I

4.1.d Cycle of expansive learning I

The fourth and last step of the activity system analysis is the analysis of the cycle of expansive learning regarding the knowledge sharing activity. Since expansive learning leads to the formation of a new, expanded object the analysis of the expansive learning cycle focuses on the contradictions which are related to the object within the activity system and are described hereafter.

The team members of the tender team *questioned* themselves about how to transfer the project information in such a way the engineering team can continue independently and both teams *analysed* that in the current situation there are too many tools and deviating and lacking roles. For the engineering team it is not clear where the information has been stored and which team member possess what project information, hence the scope of the work is not becoming clear. It becomes therefore almost impossible to take over the project which conflicts with the outcome of the tender team. Actions of questioning and analysis are aimed at finding and defining problems and contradictions behind them (Engeström, 2000).

The third strategic action in expansive learning is *modelling the new solution*. 'Modelling is already involved in the formulation of the framework and results of the analysis of contradictions, and it reaches its fruition in the modelling of the new solution, the new instrumentality, the new pattern of activity (Engeström, 2000, p. 968). The new solution is that project data is being transferred from the V-disk to Doc-stream, with different versions and lacking information as result.

This is a result of the action of *examining the new model.* The new model was not sufficient enough for transferring the information so the engineering team could not have continued independently: they needed to contact the tender team regularly and ask for additional project information. The new model has been *implemented*, but there was no *reflection* why the new model was insufficient and *consolidation of the new practice* stagnated: the engineering team could not continue independently. Further, for the lacking & deviating roles there is no *new solution being modelled*. From this perspective, the teams are stagnated in step 3 of the expansive learning cycle, they only questioned themselves why there are deviating and lacking roles and analysed that this is caused by a lack of time and capacity.

It can be concluded there is little learning since the teams do not complete the expansive learning cycle. In other words, the contradictions are not being solved by the expansive learning process of the teams.

4.2 Case II

4.2.a Identifying activities that influence knowledge sharing processes throughout teams

The two activity systems that are being analysed in case II consisted of one initiated by the tender team as subject and the other initiated by the engineering team as subject. Fig. 9 and Fig. 10 represents those activities schematically, according to the first step of the activity system analysis.

In Fig. 9, the tender team is the subject who aim for a clear UAV-GC file and little knowledge loss. The outcome intended is a shared project vision with the engineering. The tools that are used by the tender team to achieve this object are OneNote, the V-disk, a meeting and client requirements. Their main task is to finalize the files and the rules they are restricted to are having a supply and demand duty, grip 2.0 (checklist), the project files finalized and structuring the V-disk. The community of the tender team includes the project team, the departments customer & market, calculation and BIM and they are located at the tender department.

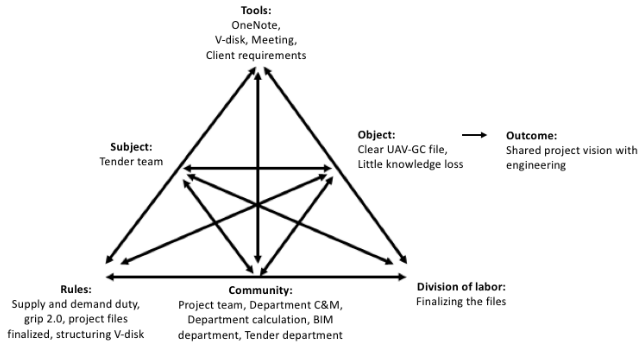

Fig. 9: The tender team activity system II

The activity system in Fig. 10 presents the activity of the engineering team aiming for receiving information and having the client requirements clear. The outcome they intend is realizing the project within budget. The tools used to attain this object are a hard copy folder, email, Doc-stream, and technical software programs (i.e. Field and Autodesk cloud). The engineering team has as main task reading the project information and the preconditions to do so are a structured folder structure and the relevance determination of information. The community of the engineering team are the project team and the calculation, BIM and engineering department.

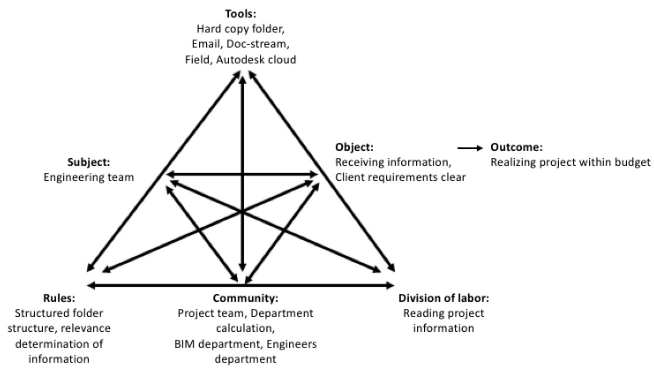

Fig. 10: The engineering team activity system II

4.2.b Identifying the shared object

According to the second step of the activity system analysis, the shared object is identified. Fig. 11 shows the activity system of the tender team from Fig. 9 and the engineering team's activity system from Fig. 10. Object 1 in this figure is the tender team object from Fig. 9 and Object 2 is the engineering team object from Fig. 10. The intersection of Object 1 and Object 2 represents the shared object. The tender team wants to have a clear UAV-GC file and little knowledge loss, whereas the engineering team wants to receive the project information and have the client requirements clear. Thus, the shared object of both teams is sharing project information. However, the activity system analysis shows that the joint activity does not guarantee that the efforts for meeting the shared object are organized and coordinated. For example, the tools used by the tender team to share information are completely different than the tools the engineering team uses. As illustrated in this example, the uncoordinated efforts for achieving the shared object brought contradictions that affected the information sharing process throughout the teams. Those contradictions are identified by executing step 3 of the activity system analysis and are described in the next section.

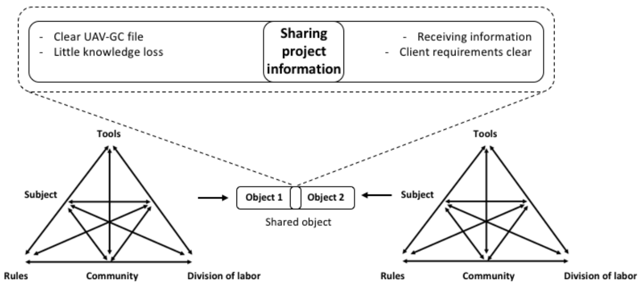

Fig. 11: Joint activities II

4.2.c Disturbances and contradictions

The third step of the activity system analysis is the identification of the contradictions. In the same way as in case I, the contradictions that lead to disturbances are represented by two-headed lightning shaped arrows, presented in Fig. 12.

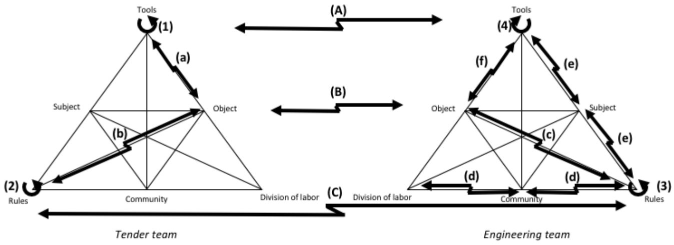

Fig. 12: The contradictions within and between the two activity systems

The first contradiction in the activity system of the tender team is within the component tools: there are too many tools used to store and share information (1). Further, there is no tool used by the tender team that is suitable to create a clear UAV-GC, resulting in a contradiction between the tools and the object (a). Further, between the object and rules a contradiction arise (b). In the current situation, grip 2.0 function as a checklist but is not sufficient enough to create a clear UAV-GC file and knowledge loss becomes a risk. Regarding the rules, project files need to be finalized in order to structure the V-disk. However, not all project files were completed at the moment of sharing the project information (i.e. the shared object), so it was not possible for the tender team to structure the V-disk (2).

Within the activity system of the engineering team the first contradiction is between the rules and the object (c). Receiving information was complex because of an unstructured folder structure, and therefore the relevance determination of information was not possible, leading to another inner contradiction within the component rules (3). Since relevance determination was not possible, the engineering team could not execute her task efficiently. Leading to a contradiction between rules and division of labor via the community (d). Following the rule of having a structured folder structure is becoming complex if different tools are being used by the engineering team to share information, leading to a contradiction between the tools and rules via the subject (e). The use of different tools leads also to an inner contradiction within the component tools (4). Due to this contradiction, having too many tools to receive information, it is difficult to receive information and get the client requirements clear (f).

As a result of the shared object, the activity systems of the tender team and the engineering team are interwoven. However, there are also objects conflicting to each other and there is a growing tension between them. This growing tension is illustrated by the two-headed lightning shaped arrows numbered in capital letters in Fig. 12. The first is between the component tools (A), both teams use different storage media: the tender team uses the V-disk and the engineering team uses Doc-stream. The objects of both systems conflicts (B), getting the client requirements clear is becoming impossible since there is no clear UAV-GC file produced by the tender team. This was caused by unfinished project files at the moment of sharing the project information, and it was therefore not possible for the engineering team to determine the relevance of the information. Resulting in a contradiction between the components rules of both activity systems (C). According to Engeström and Sannino (2010, p. 6), this deteriorating situation can be changed by means of an expansive learning process in which the two parties together generate a new shared object and concept for their shared activity.

4.2.d Cycle of expansive learning

The fourth and final step of the activity system analysis is then the analysis of the cycle of expansive learning regarding the knowledge sharing activity.

As mentioned before in case I, the analysis of the expansive learning cycle focuses on the contradictions related to the object within the activity system since expansive learning leads to the formation of a new, expanded object. The analysis of the expansive learning cycle is described below.

In case II, both teams established that there are too many different tools to share information among the teams by *questioning* themselves about why knowledge sharing from tender to engineering is problematic. However, by *analysing* the situation it has been concluded that there is no common tool available yet that is suitable to use by both teams. Hence, the current solution in the current situation is transferring the project information from the V-disk to Doc-stream. Since both tools are commonly accepted and has thus been *examined* by both teams, they are *implemented* to share project information. However, there is no *reflection* and *consolidation* since the new expansive cycle of learning starts again by *questioning* why different tools are not working but no new solution has been modelled.

It can be concluded there is little learning since the teams do not complete the expansive learning cycle. The contradictions are not being solved by the expansive learning process of the teams.

4.3 Cross-case analysis

To identify the main problems according to the research goal, a cross case analysis has been done based on the results from the activity system analysis in case I and II. The findings of both cases were compared to identify comparisons and/or differences (Table 2).

First, in both cases the shared object is sharing project information. Although, in both cases the object between the tender team and engineering team is conflicting. The tender team aims a client-oriented object while the engineering team aims a technical-commercial object. Second, in both cases the contradiction within the component tools of using too many tools arise, as well in the tender team as in the engineering team different tools are being used to share and store information. Third, in both cases the contradiction of two different tools that are conflicting appear between both activity systems. Fourth, in the first case the division of labor causes disturbances: there were deviating, lacking and double roles when knowledge had to be shared throughout the teams. In the second case this is not the case, all team members were present at the moment of sharing knowledge throughout the teams. Fifth, in case two the rules could not be followed resulting in an inner contradiction within the component rules. Further, the rules of the tender team conflicts with the rules of the engineering team since those have not been followed during the activity. In the first case, there are no disturbances regarding the rules component.

Sixth, in both cases the activity systems of all teams show that the tools have a negative influence on achieving the object. Seventh, in the first case the activity system of the tender team shows that the rules have a negative influence on the division of labor and in the second case the activity system of the engineering team shows that. Eighth, in the first case the division of labor impedes the achievement of the object, for both the tender team and the engineering team. In the second case, this has not been recognized. Ninth, in both cases the activity system of the engineering team shows disturbances between the tools and rules: a structured folder structure is hardly possible when there are so many different tools to store and share project information with. And finally, in the second case the rules influence the achievement of the object negatively: those are not sufficient enough.

As regards the cycle of expansive learning, in both cases both the teams stagnated at step 6: reflecting on the process. This makes consolidation and generalization of the new practice impossible. Since the cycle of expansive learning is not being completed, there is little learning in the knowledge sharing process both in case I and case II.

Table 2: Similarities and differences between cases regarding the shared object, the contradictions and the cycle of expansive learning

	Case I		**Case II**	
Subject	*Tender team*	*Engineering team*	*Tender team*	*Engineering team*
		Shared object		
	Knowledge sharing		Knowledge sharing	
		Contradictions		
Object	Client-oriented object vs. technical-commercial object		No clear UAV-GC file vs. client requirements clear	
Tools	Too many tools	Too many tools	Too many tools	Too many tools
	V-disk vs. Doc-stream		V-disk vs. Doc-stream	
Division of labor	Deviating and double roles	Lacking roles		
	Project manager part of engineering team instead of tender team			
Community				
Rules			Structuring V-disk not possible	Relevance determination of information not possible
			Unfinished project files vs. relevance determination of information	
Tools vs. Object	Using different tools hampers the transference of information	Receiving project information via different channels makes it hard to get the scope of work clear	No tool used to create a UAV-GC file	Too many tools impede receiving information and getting the client requirements clear
Rules vs. Division of labor	All team members present is not possible due to deviating roles			Reading project information was complex since relevance determination was not possible
Division of labor vs. Object	Transferring information is becoming hard since persons who possess important project knowledge are missing	Project leader is missing although he is needed to take over the project		
Tools vs. Rules		Using different tools makes it difficult to have a structured folder structure		Using different tools makes it difficult to have a structured folder structure
Rules vs. Object			Grip 2.0 does not suffice as checklist to create a clear UAV-GC file	Receiving information was complex because of an unstructured folder structure and relevance determination became impossible
		Cycle of expansive learning		
Questioning	How to transfer project information?		Why is knowledge sharing problematic?	
Analysis	Too many tools and deviating and lacking roles		No common tool available suitable to use by both teams	
Modelling new solution	Transferring data from V-disk to Doc-stream		Transferring data from V-disk to Doc-stream	
Examining new model	Different versions and lacking information as result		Different versions and lacking information as result	
Implementing new model	Engineering team contacts tender team regularly for additional project information		Commonly accepted tools	
Reflecting on process	No reflection		No reflection	
Consolidating and generalizing new practice	No consolidation because engineering team could not continue independently		No consolidation because cycle starts again by questioning the current problematic situation	

5 CONCLUSION

To conclude, in both cases the tools influences the activity systems of both the tender and engineering team negatively. Referring back to the cycles of expansive learning (I & II), in both cases the teams *questioned* themselves about the problems regarding the sharing of project information and *analysed* that this is caused by the usage of too many different tools. The *new model* they contrive is transferring the information from one tool to the other, however the *examination* is about the commonly accepted use of different tools and the *implementation* stuck at this traditional way of sharing information. The teams do not *reflect on the process* so there is no *consolidation of the new practice*. The teams move directly on to the first step of the learning cycle (Fig. 13): questioning the current situation and the problems remain. Hence, there is somewhat learning but there is room for improvement.

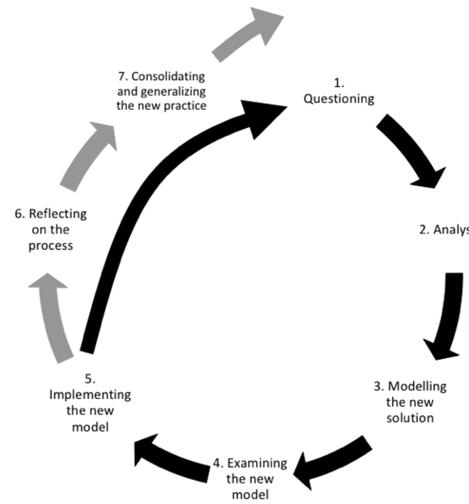

Fig. 13: Cycle of expansive learning adapted from Engeström (1999, 2000)

6 RECOMMENDATIONS

To improve the knowledge sharing between the two teams, there should be expansive learning.
The expansive learning cycle of the new learning process should be completed in order to consolidate new practice. New practice implies new tools, new rules, another community, another division of labor and even a new object. To improve the knowledge sharing process between tender team and engineering team in D&B projects, it is recommended to change the current tools and rules. Knowledge sharing requires a joint object to exchange knowledge (Lin et al., 2012; Ramim & Lichvar, 2013; Snippert et al., 2015; Yang et al., 2012). However, achieving the joint object has been interfered by too many different tools that were used to share knowledge. There is no standard that is familiar to all team members, which is in conflict with the theory: choose for using one standard tool being familiar to all team members in order to be able to share knowledge (Jackson & Klobas, 2008; Lee, Kim, & Kim, 2006; Venkatesh, Morris, Davis, & Davis, 2003). It is therefore recommended for the construction company to examine one standard tool familiar to all project team members.
Further, a standardized process scheme is recommended to improve the knowledge sharing process. By implementing this scheme as a new rule during the transition process, organisational and technical barriers such as discontinuity of the inter-project information flow, lack of systematic vision, and lack of technology tools are being tackled (Frank & Echeveste, 2012; Hermann, 2011; McLaughli, Paton, & Macbeth, 2008; Mueller, 2015; Riege, 2005; Santos, Soares, & Carvalho, 2012).
Nevertheless, to tackle those barriers the learning cycle should be traversed until consolidation of the new practice is possible: the standardized process scheme becomes common practice (Barab et al., 2003; Engeström, 2000; Engeström & Sannino, 2010).
Implementing a standardized process scheme might lead to new roles and responsibilities for both members of the tender and engineering team (division of labor) that operates in a new project environment (community). This might lead to a new object the tender team and engineering team should pursue together.

7 IMPLEMENTING RECOMMENDATIONS IN PRACTICE

As a result of the inefficient knowledge sharing processes between the tender team and engineering team, the management of the construction company designed a standardized process scheme that is oriented to the new procedures of D&B UAV-GC contracts. This scheme includes the tasks, the corresponding roles and responsibilities, the scheduled timeline the project should proceed within and a standard for document management. This standardized process scheme aims at resolving the contradictions depicted in Fig. 8 and Fig. 12 by creating a tool. This tool, when used by both teams, is supposed to improve the knowledge sharing process by creating a format about how to share and store project information in a common and standardized way. The model in Fig. 14 implies an expansion of the object of activity for both teams: from sharing information through a project dependent approach to a standardized approach, and from multiple tools to a standardized document management tool.

Expansive learning typically calls for interventions based on the principle of double stimulation (Engeström & Sannino, 2010). The new tool functions as double stimulation since it leads to the reframing of the tasks of all project team members. This gradually lead to a new solution which changes the activity system of the knowledge sharing activity.

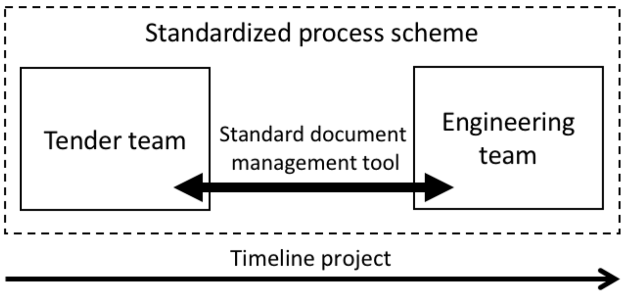

Fig. 14: Model for the knowledge sharing process throughout teams

The model provides a framework that functions as rule in the activity of sharing project information throughout teams. The model is a driving force of the zone of proximal development of the activity systems involved (Engeström, 2000), an instrument for traversing "the distance between the present everyday actions of the individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potentially embedded in the everyday actions" (Engeström, 1987, p. 174). According to Engeström (2000) a new type of learning process was needed to achieve such an expansion both conceptually and in practice. Fig. 15 illustrates the zone of proximal development that needs to be traversed in order to move beyond the existing contradictions (Engeström & Sannino, 2010) and charts the expansion of concept and practice.

The zone of proximal development lies in the peak moment of knowledge sharing between the two teams: the kick off meeting. At the same time, during this meeting a tension arise between the two teams. This tension is mainly caused by the use of different tools and the deviating and lacking roles regarding the team members, therefore the rules cannot be followed and achievement of the shared object is being interfered.

The model as illustrated in Fig. 14 provides a new solution to the tension arising within the zone of proximal development and is an example of the third step of the expansive learning cycle. Prior to this the team members analysed (step 2) this tension by asking themselves critical questions (step 1) why the transition is being experienced problematic.

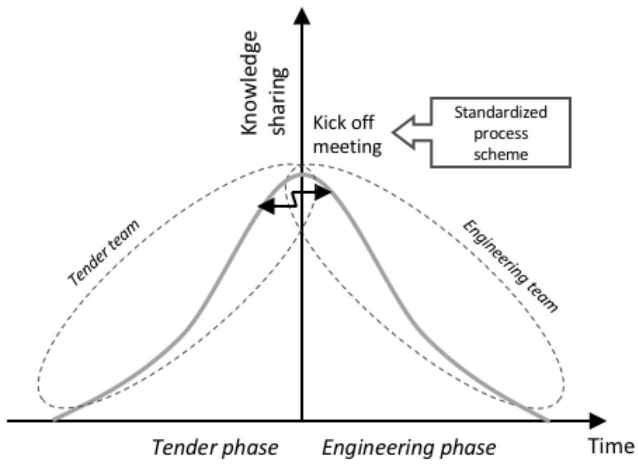

Fig. 15: Zone of proximal development

The standardized process scheme is being discussed within the management team and the project team and is accepted as possible solution for the problematic transition, which is an example of examining the new model (step 4).

For the construction company this new learning process stops here, hence the cycle of expansion is not completed yet and thus the contradictions are not being solved. For now, there is little learning regarding the information sharing process since the new model has not been implemented yet and no reflection on this process has been taken place. Consolidation of the new practice is not possible so far.

To improve the information sharing between the two teams, the expansive learning cycle should be completed in order to finish the new learning process regarding the standardized process scheme. The new model should be implemented as a standardized process scheme for the D&B projects and there should be a reflection of this scheme by both the project team and management team in order to use it as a standard for all D&B projects.

8 LIMITATIONS AND FUTURE RESEARCH

The Activity Theory has been used as analytical framework to analyse the practice of knowledge sharing activities. The framework offered the researcher insights to the problems experienced by the team members, and to clarify why the transition was experienced problematic. However, there were two limitations to be noticed. First, there is no accepted methodology for using the Activity Theory, although it is a generic multidisciplinary research approach (Barab et al., 2003). The way the theory is used in this research, is defined by the researcher itself inspired on Engeström (2000); Engeström and Sannino (2010); Yamagata-Lynch and Haudenschild (2009); Zahedi et al. (2017). Second, the model enquires some prior knowledge about the theory and its system, since the participants found it difficult to understand and fill in the model during the interview. An additional risk here is that the elements of the system are interpreted by the researcher herself, even though the answers of the questions were based on those elements. Validation sessions with the participants were organised to reduce this interpretation risk.

The focus of this research lied on the transition from tender phase and engineering phase. However, it might also be interesting to research other transition moments the construction company encounters, because during the interviews the members of the engineering team mentioned a lot of issues that took place in the next phase: the realisation phase. A cross-case analysis of the findings from all transition moments would provide a more complete overview concerning the industrial D&B UAC-IC projects.

REFERENCES

Ajmal, M. M., & Koskinen, K. U. (2008). Knowledge Transfer in Project-Based Organizations: An Organizational Culture Perspective. *Project Management Journal, 39*(1), 7-15.

Akkerman, S. (2012). Activity theory - Yrjö Engeström. In M. Ruijters & R. J. Simons (Eds.), *Canon van het leren* (1st ed., pp. 51-64): Kluwer.

Almeida, M. V., & Soares, A. L. (2014). Knowledge sharing in project-based organizations: Overcoming the informational limbo. *International Journal of Information Management, 34*(6), 770-779. doi:10.1016/j.ijinfomgt.2014.07.003

Barab, S. A., Barnet, G. M., Yamagata-Lynch, L. C., Squire, K., & Keating, T. (2002). Using activity theory to understand the contradictions characterizing a technology-rich introductory astronomy course. *Mind, Culture, and Activity, 9*(2), 76-107.

Barab, S. A., Evans, M. A., & Baek, E. (2003). Activity theory as a lens for characterizing the participatory unit. *International Handbook on Communication Technologies, 2*, 199-214.

Barab, S. A., Schatz, S., & Scheckler, R. (2004). Using activity theory to conceptualize online community and using online community to conceptualize activity theory *Mind, Culture, and Activity, 11*(1), 25-47.

Boer, N.-I., van Baalen, P. J., & Kumar, K. (2002). *An Activity Theory Approach for Studying the Situatedness of Knowledge Sharing*. Paper presented at the Proceedings of the 35th Hawaii International Conference on System Sciences, Big Island, Hawaii.

Buvik, M. P., & Rolfsen, M. (2015). Prior ties and trust development in project teams – A case study from the construction industry. *International Journal of Project Management, 33*(7), 1484-1494. doi:10.1016/j.ijproman.2015.06.002

Chaiklin, S., Hedegaard, M., & Jensen, U. J. (Eds.). (1999). *Activity Theory and Social Practice* Aarhus: Aarhus University Press.

Cheung, L. (2015). *Research into the influence of mutual trust between the Client and the Contractor on the efficiency and the effectiveness of the change management process for complex D&B infrastructure projects using the UAC-IC 2005.* (Master thesis), TU Delft, Delft.

Daspit, J., Justice Tillman, C., Boyd, N. G., & McKee, V. (2013). Cross-functional team effectiveness. *Team Performance Management: An International Journal, 19*(1/2), 34-56. doi:10.1108/13527591311312088

Devers, K. J. (1999). How will we know "good" qualitative research when we see it? Beginning the dialogue in health services research. *Health Service Research, 34*(5), 1153-1188.

Ding, Z., Ng, F., & Cai, Q. (2007). Personal constructs affecting interpersonal trust and willingness to share knowledge between architects in project design teams. *Construction Management and Economics, 25*(9), 937-950.

Ding, Z., Ng, F., & Li, J. (2014). A parallel multiple mediator model of knowledge sharing in architectural design project teams. *International Journal of Project Management, 32*(1), 54-65.

Eastman, C., Techolz, P., Sacks, R., & Liston, K. (2011). *BIM Handbook*. New Jersey: John Wiley & Sons Inc.

Eisele, P. (2013). Validation of the Team Diagnostic Survey and a Field Experiment to Examine the Effects of an Intervention to Increase Team Effectiveness. *Group Facilitation: A Research and Applications Journal, 12*, 53-70.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14*(4), 532-550.

Engeström, Y. (1987). *Learning by expanding: an activity theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.

Engeström, Y. (1993). *Developmental studies of work as a testbench of activity theory: The case of primary care medical practice*. Cambridge: Cambridge University Press.

Engeström, Y. (1996). Developmental work research as educational research: looking ten years back into the zone of proximal development. *Nordisk Pedagogik, 16*(3), 131-143.
Engeström, Y. (1999). *Perspectives on Activity Theory*. Cambridge: Cambridge University Press.
Engeström, Y. (2000). Activity theory as a framework for analyzing and redesigning work. *Ergonomics, 43*(7), 960-974. doi:10.1080/001401300409143
Engeström, Y. (2001). Expansive Learning at Work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133-156. doi:10.1080/13639080020028747
Engeström, Y., Miettinen, R., & Punamäki, R.-L. (Eds.). (1998). *Innovative learning in work teams: analyzing cycles of knowledge creation in practice*. Cambridge: Cambridge University Press.
Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review, 5*(1), 1-24. doi:10.1016/j.edurev.2009.12.002
Fong, P. S., & Kwok, C. W. C. (2009). Organizational culture and knowledge management success at project and organizational levels in contracting firms. *Journal of Construction Engineering and Management, 135*(12), 1348-1356.
Frank, A., & Echeveste, M. (2012). Knowledge transfer between NPD project teams: A method for the identification of improvement opportunities. *International Journal of Quality & Reliability Management, 29*(3), 242-264.
Fujioka, M. (2014). L2 student–U.S. professor interactions through disciplinary writing assignments: An activity theory perspective. *Journal of Second Language Writing, 25*, 40-58. doi:10.1016/j.jslw.2014.05.004
Hasan, H. (1999). Integrating IS and HCI using AT as a Philosophical and Theoretical Basis. *Australian Journal of Information Systems, 6*(2), 44-55.
Hasan, H., & Kazlauskas, A. (2014). *Activity Theory: who is doing what, why and how*. Wollongong, Australia: THEORI.
Hermann, N. (2011). Barriers for an efficient Management of Knowledge: Experiences from a Southern African Organization. *Journal of Knowledge Management, 3*, 1-15.
Hong, D., Suh, E., & Koo, C. (2011). Developing strategies for overcoming barriers to knowledge sharing based on conversational knowledge management: A case study of a financial company. *Expert Systems with Applications, 38*(12), 14417-14427. doi:10.1016/j.eswa.2011.04.072
Huang, C.-C. (2009). Knowledge sharing and group cohesiveness on performance: An empirical study of technology R&D teams in Taiwan. *Technovation, 29*(11), 786-797. doi:10.1016/j.technovation.2009.04.003
Jackson, P., & Klobas, J. (2008). Building knowledge in projects: A practical application of social constructivism to information systems development. *International Journal of Project Management, 26*(4), 329-337. doi:10.1016/j.ijproman.2007.05.011
Javernick-Will, A. (2011). Motivating knolwedge sharing in engineering and construction organizations: Power of social motivations. *Journal of Management in Engineering, 28*(2), 193-202.
Kale, S. (2011). Evaluating the knowledge management practices of construction firms by using importance-comparative performance analysis maps. *Journal of Construction Engineering and Management, 137*(12), 1142-1152.
Kaptelinin, V., & Nardi, B. (2012). *Activity Theory in HCI: Fundamentals and Reflections*: Morgan&Claypool Publishers.
Lee, J. H., Kim, Y. G., & Kim, M. Y. (2006). Effects of managerial drivers and climate maturity on knowledge-management performance: Empirical validation. *Information Resources Management Journal, 19*(3), 48-60.
Leontiev, A. N. (1978). *Acitivity. Consciousness. Personality.* . Englewood Cliffs, NJ.: Prentice-Hall.
Lin, T. C., Wu, S., & Lu, C. T. (2012). Exploring the affect factors of knowledge sharing behavior: The relations model theory perspective. *Expert Systems with Applications, 39*(1), 751-764.
Male, S., Bower, D., & Aritua, B. (2007). Design management: changing roles of the professions. *Proceedings of the Institution of Civil Engineers - Management, Procurement and Law, 160*(2), 75-82. doi:10.1680/mpal.2007.160.2.75
Maunula, A., Riitta, S., & Hirvensalo, A. (2008). *Implementation of Building Information Modeling (BIM) - A process perspective*. Paper presented at the Innovations in Networks - Proceedings of the APMS 2008 Conference, An Event of the IFIP Working Group.
McLaughli, S., Paton, R. A., & Macbeth, D. (2008). Barrier Impact on Oragnizational Learning with Complex Organization. *Journal of Knowledge Management, 12*(2), 107-123.
Mueller, J. (2015). Formal and Informal Practices of Knowledge Sharing Between Project Teams and Enacted Cultural Characteristics. *Project Management Journal, 46*(1), 53-68.
Nidumolu, S. R., Subramani, M., & Aldirch, A. (2001). Situated learning and the situated knowledge web: Exploring the ground beneath knowledge management. *Journal of Management Information Systems, 18*(1), 115-150.
Plakitsi, K. (2013). *Activity Theory in Formal and Informal Science Education*. Rotterdam: Sense Publishers.
Ramim, M. M., & Lichvar, B. T. (2013). Effective collaboration and knowledge sharing in short vs. long term SD projects. *Online Journal of Applied Knowledge Management, 1*(1), 133-147.
Reich, B. H., Gemino, A., & Sauer, C. (2014). How knowledge management impacts performance in projects: An empirical study. *International Journal of Project Management, 32*(4), 590-602. doi:10.1016/j.ijproman.2013.09.004
Rezgui, Y., Hopfe, C. J., & Vorakulpipat, C. (2010). Generations of knowledge management in the architecture, engineering and construction industry: An evolutionary perspective. *Advanced Engineering Informatics, 24*(2), 219-228. doi:10.1016/j.aei.2009.12.001
Riege, A. (2005). Three-dozen Knowledge-sharing Barrers Managers Must Consider. *Journal of Knowledge Management, 9*(3), 18-35.
Rochelle, J. (1998). Activity theory: A foundation for designing learning technology? *The Journal of the Learning Sciences, 7*(2), 241-255.
Santos, V. R., Soares, A. L., & Carvalho, J. Á. (2012). Knowledge Sharing Barriers in Complex Research and Development Projects: an Exploratory Study on the

Perceptions of Project Managers. *Knowledge and Process Management, 19*(1), 27-38. doi:10.1002/kpm.1379

Snippert, T., Witteveen, W., Boes, H., & Voordijk, H. (2015). Barriers to realizing a stewardship relation between client and vendor: the Best Value approach. *Construction Management and Economics, 33*(7), 569-586. doi:10.1080/01446193.2015.1078902

Solli-Saether, H., Karlsen, J. T., & van Oorschot, K. (2015). Strategic and Cultural Misalignment: Knowledge Sharing Barriers in Project Networks. *Project Management Journal, 46*(3), 49-60.

UvA, N. K. O. A.-. (2002). *Richtlijnen voor kwaliteitsborging in gezondheids(zorg)onderzoek: Kwalitatief Onderzoek*. Retrieved from Amsterdam:

Van Vlaenderen, H. (2001). Evaluating development programs: building joint activity. *Evaluation and Program Planning, 24*, 343-352.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psycological processes.* Cambridghe: Harvard University Press.

Wang, Z., & Wang, N. (2012). Knowledge sharing, innovation and firm performance. *Expert Systems with Applications, 39*(10), 8899-8908.

Waycott, J., Jones, A., & Scanlon, E. (2005). PDAs as lifelong learning tools: An AT based Analysis. *Learning, Media, and Technology, 30*(2), 107-130.

Wen, Q., & Qiang, M. (2016). Coordination and Knowledge Sharing in Construction Project-Based Organization: A Longitudinal Structural Equation Model Analysis. *Automation in Construction, 72*, 309-320. doi:10.1016/j.autcon.2016.06.002

Yamagata-Lynch, L. C. (2003). Using activity theory as an analystical lens for examining technology professional development in schools. *Mind, Culture, and Activity, 10*(2), 100-119.

Yamagata-Lynch, L. C., & Haudenschild, M. T. (2009). Using activity systems analysis to identify inner contradictions in teacher professional development. *Teaching and Teacher Education, 25*(3), 507-517. doi:10.1016/j.tate.2008.09.014

Yang, X., Dong, A., & Helander, M. (2012). The analysis of knowledge integration in collaborative engineering teams. *Journal of Engineering Design, 23*(2), 119-133.

Zahedi, M., Tessier, V., & Hawey, D. (2017). Understanding Collaborative Design Through Activity Theory. *The Design Journal, 20*(sup1), S4611-S4620. doi:10.1080/14606925.2017.1352958

Zhang, L., & Cheng, J. (2015). Effect of Knowledge Leadership on Knowledge Sharing in Engineering Project Design Teams: The Role of Social Capital. *Project Management Journal, 46*(5), 111-124.

Zhang, P., & Ng, F. F. (2013). Explaining knowledge-sharing intention in construction teams in Hong Kong. *Journal of Construction Engineering and Management, 139*(3), 280-293.

Zhao, Z.-Y., Tang, C., Zhang, X., & Skitmore, M. (2017). Agglomeration and Competitive Position of Contractors in the International Construction Sector. *Journal of Construction Engineering and Management, 143*(6). doi:10.1061/(asce)co.1943-7862.0001284

University of Twente & Dura Vermeer Bouw Hengelo BV

AN ACTIVITY THEORY ANALYSIS TO KNOWLEDGE SHARING FROM TENDER PHASE TO ENGINEERING PHASE IN D&B PROJECT TEAMS

NEDERLANDSTALIGE SAMENVATTING

Sophie Roesthuis, June 2018

SAMENVATTING

In bouwbedrijven is de overgang van aanbestedingsfase naar engineeringfase in de projectlevenscyclus vaak problematisch. Tijdens een dergelijke overgang moet de kennis van het projectteam in de aanbestedingsfase worden gedeeld met het projectteam in de engineeringfase.
Deze studie richt zich op het kennis delen van tender fase naar engineering fase in D&B-projectteams en vond plaats bij een Nederlands bouwbedrijf. De belangrijkste onderzoeksvraag in dit onderzoek is hoe de overgang van tenderfase naar engineeringfase in complexe D&B UAV-GC-utiliteitsprojecten kan worden verbeterd. Interviews met teamleden van het projectteam waren de primaire gegevensbron in deze studie. De activiteitentheorie wordt gebruikt als kwalitatief analytisch kader.
De bevindingen laten zien dat er in het projectteam afwijkende en ontbrekende rollen zijn en dat door het gebruik van verschillende tools de kennisuitwisseling wordt belemmerd. Om het kennisuitwisselingsproces te verbeteren, moet het projectteam leren door te groeien: van het delen van informatie via een projectafhankelijke benadering tot een gestandaardiseerde aanpak en van meerdere tools tot een gestandaardiseerde documentbeheerstool die door het projectteam moet worden beoordeeld.