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Unraveling the Process of Knowledge Integration in Agile Product Development Teams

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Abstract

Agile product development seems to be the solution for many companies to drive innovation and shorten time-to-market, but what mechanisms lie behind the promises of faster development times and more innovative products? Defined as locus of innovation and driver of dynamic performance, the concept of cross-functional knowledge integration and the organizational learning literature have the potential to provide answers here. Recent empirical studies imply that knowledge integration happens on multiple levels that influence each other, and that environmental uncertainty leads to changes in the knowledge integration process. However, the interplay of individual-level and group-level knowledge integration has not yet received adequate attention and prior studies do not show how knowledge integration changes over shorter periods of time. This paper takes a grounded theory approach to explore the knowledge integrating mechanisms in two agile product development teams. The resulting iterative process model shows how agile teams integrate diverse contributions of individual team members into a new product, how internal and external factors trigger alterations in knowledge integration practices, and how agile teams adapt to changes in coordination and collaboration demands.

Keywords: Agile product development; knowledge integration; cross-functional teams; organizational learning.

1. Introduction

With the growing need for flexibility and reactivity of companies to successfully compete in an increasingly complex and ambiguous environment, practitioners and scholars have begun to search for organizational designs and management approaches that enhance innovative performance and fit a dynamic world. Over the last few years the buzzword "agile" has been appearing in numerous popular scientific papers and books on management providing guidance for organizations to becoming "agile", which is often referred to as being flexible and adaptive (Hasenzagl & Link, 2017, p. 47). Agile innovation methods, like Scrum or Design Thinking, have been contributing to software development success for 30 years, being proposed to improve quality and time-to-market of the products as well as motivation and productivity in the product development teams (Rigby, Sutherland, & Takeuchi, 2016, p. 41). More recently, the benefits and enhancements that the implementation of agile values, principles, and practices promise, have induced companies of other industries to adopt the agile management approach that radically differs from traditional command-and-control-styles, for enhancing product development, marketing, HR and strategy making (Rigby et al., 2016, p. 42). An integral part of the agile principles, established for software development, is the implementation of self-organizing teams composed of motivated individuals from diverse functions or areas of expertise that shall receive the support they need and be trusted to achieve the successful completion of a project (Beedle et al., 2001). This central requirement coincides with the general trend inherent in organizations to structure around teams rather than individuals. However, research on agile teams outside the software development context remains scarce, raising questions of whether the positive effects that the agile methodology promises can also be achieved in other settings and if so, what the mechanisms behind increased quality and time-to-market are.

The literature on new product development has long been dealing with the factors that determine new product success. An aspect that has been receiving considerable attention is the role of cross-functional teams in achieving innovative outcomes. For example, in the rugby approach to new product development, that serves as a theoretical foundation for Scrum, multidisciplinary teams represent a central feature (Takeuchi & Nonaka, 1986, p. 138). Cross-functional team

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compositions, entailing not only different functional specializations, but also diverse thought processes and behavioral patterns, are thereby proposed to foster new ideas and concepts (Takeuchi & Nonaka, 1986, p. 140). Thus, the proposed value of the team approach is based on the incorporation of different perspectives and expertise from different domains to collective task completion (Edmondson & Nembhard, 2009, p. 125). In general, there is consensus in the literature on new product development that effective cross-functional teamwork is critical to team performance and new product success (S. Brown & Eisenhardt, 1995). For example, in their study of software development teams, Faraj and Sproull (2000, p. 1564) found a strong relationship between expertise coordination, i.e. the management of skill and knowledge dependencies, and team performance. Similarly, Hoegl and Gemuenden (2001, p. 437) showed that coordination, defined as "the degree of common understanding regarding the interrelatedness and current status of individual contributions", improved team work quality and subsequently team performance in 145 German software development projects. In providing a structure for the integration of diverse skill sets, perspectives, and other specialist knowledge, the cross-functional team enables the timely exposure of interdependencies across functions early in the new product development process, where corrections are rather easy and inexpensive (Edmondson & Nembhard, 2009, p. 126).

Likewise, the literature on organizational learning acknowledges the value of the cross-functional team for creating new knowledge, e.g. in the form of product or process innovations, through integrating diverse knowledge bases. For example, Leonard-Barton (1995, p. 64) suggests the locus of innovation to lie at the boundaries between specializations and their respective mindsets. Similarly, Nonaka (1994, p. 24) describes the cross-functional team "as the basic building block for structuring the organizational knowledge creation process". However, innovating through integrating knowledge from diverse sources has been representing a core challenge for organizations ever since (Carlile & Rebentisch, 2003, p. 1181). Knowledge differences have been suggested to hinder the performance of cross-functional teams by complicating knowledge integration, especially under novel or uncertain circumstances (Majchrzak, More, & Faraj, 2012, p. 951). The organizational learning literature offers two partly contradicting perspectives on how the specialized knowledge of individuals can be successfully integrated into organizational knowledge (Grunwald, 2003, p. 3): a "cross-learning" perspective suggesting that knowledge needs to be transferred between specialists and combined in their individual brains to enable organizational learning (Kieser & Koch, 2008, p. 331) and a specialization perspective promoting the exertion of structural mechanisms to reduce knowledge transfer, thus accounting for individuals' limited cognitive capacities and economizing on specialization (Grant, 1996, p. 114; Kieser, Beck, & Tainio, 2001, p. 600).

Thus far, contemporary empirical research seems to agree that knowledge integration may involve merely mentioning and demonstrating knowledge, rather than a "deep" sharing of interpretations and interests (Mengis, Nicolini, & Swan, 2018, p. 597). However, extant research also suggests that the intensity of knowledge sharing in teams depends on the novelty and uncertainty they face. For example, Schmickl and Kieser (2008, p. 485) found that the more radical the innovation, the more knowledge was exchanged between project members (Schmickl & Kieser, 2008, p. 485). Furthermore, research that frames knowledge integration as a process rather than an outcome implies that the process of integrating knowledge may change over time (Mengis et al., 2018, p. 598). Studies of this kind especially highlight that knowledge integration progresses between phases of "working together alone" (Bruns, 2013; Enberg, Lindkvist, & Tell, 2006) and phases of closer interaction. While most of the studies on cross-functional teams in new product (e.g. Schmickl & Kieser, 2008) or new process development (e.g. Majchrzak et al., 2012) consider the overall level of uncertainty and its impact on knowledge integration, they do not show how knowledge integration mechanisms and practices change over time within the course of a project. However, unexpected problems or changes in customer demand that increase task uncertainty and novelty may prompt the reliance on coordination mechanisms other than those currently in place (Grant, 1996, p. 113). Finally, despite prior research evidenced the mutual influence of individual and collective knowledge integrating practices (Enberg et al., 2006), thereby implying the need for of a multi-level perspective on knowledge integration processes, the interplay of individual-level and group-level knowledge integration practices has not yet received adequate attention in empirical research on knowledge integration in new product development teams.

To shed light on the success factors of agile teamwork, i.e. the mechanisms behind increased product quality and time-to-market, this master's thesis adopts a process-based view of knowledge integration and deals with changes in knowledge integration practices and mechanisms over the course of agile product development projects and how agile teams cope with such deviations. Agile product development is characterized by its great flexibility in dealing with changes in market demand or technology and in shortening the time-to-market of new products or services. However, the promises of speed and flexibility should not be misleading, because the agile methodology goes hand in hand with a tightly structured process that requires precise planning and includes regular meetings, recurring ceremonies, and other formal coordination mechanisms. Therefore, this product development method is ideally suited to observe the effect of changes in coordination and collaboration requirements, triggered by unexpected changes or emerging uncertainties, on formal and informal mechanisms and practices within the course of a project.

The research method used is consistently qualitative. In taking a grounded theory approach according to the guidelines of the Gioia methodology (Gioia, Corley, & Hamilton, 2013), the knowledge integrating mechanisms and practices in two different agile product development teams of an Aus-

trian manufacturing company specialized in the development and production of special machinery and associated spare parts were explored. Data were predominantly collected through semi-structured interviews with 14 individuals from the teams, including all three roles in agile product development. The fully transcribed interviews and the associated research notes were analyzed by being subjected to a first-order and a second-order analysis as suggested by Gioia et al. (2013). Ultimately, an iterative process model of knowledge integration in agile product development projects in the manufacturing industry that accounts for changes and adaptions in knowledge integration mechanisms and practices was developed. The proposed model shows that the process of knowledge integration in agile new product development teams iterates between group-level practices, in which coordination-related and problem-centered knowledge exchange take place, and individual-level practices, in which team members individually process the information they receive and integrate their cognition in their individual contributions to the project. Knowledge integration in this model is aided by support mechanisms such as a shared information base, physical and psychological proximity, transparency of responsibilities, and project leadership. These mechanisms, individually and in combination, reduce the need for extensive coordination-related knowledge sharing among team members. However, as will be shown, internal conflicts potentially disrupt the effectivity of these mechanisms in reducing knowledge exchange by making cross-functional communication difficult and forcing an increase in conflict resolution measures. Furthermore, uncertainty and novelty temporarily increase the need for both coordination-related and problem-centered knowledge exchange, hampering the routine knowledge integration process, which gets by without an intensive exchange of knowledge. To cope with these disruptive factors, team members increasingly engage in dialogical knowledge exchange, in the form of group-problem-solving and decision-making as well as bilateral exchanges outside the planned meetings, for a short time, leading to structural adaptions in some cases. The model that will be developed in the results section thus represents an iterative process model of knowledge integration that shows (a) how agile teams integrate the diverse contributions of the individual team members into a new product, (b) how internal and external factors trigger alterations in knowledge integration practices, and (c) how agile teams adapt to the resulting changes in coordination and collaboration demands.

The present study contributes to the organizational learning literature on knowledge integration in three ways. First, it provides an understanding about the contingencies that determine the depth of knowledge exchange in project teams and the effectiveness of structural support mechanisms in reducing the need for extensive knowledge sharing. In doing so, the consistent substitutive effect on knowledge exchange that is attributed to structural support mechanisms (e.g. Schmickl & Kieser, 2008) is called into question. It rather appears that the effectiveness of support mechanisms varies over the course of a project, depending on the project phase, the project context, and the quality of teamwork. Furthermore, while prior studies have discovered that the degree of innovation of a project determines the depth of knowledge integration (Majchrzak et al., 2012, p. 958; Schmickl & Kieser, 2008, p. 485), the present study implies that disruptions trigger changes in the depth of knowledge integration within the course of a project, temporarily increasing the need for deep-level knowledge exchange among experts. Second, empirical insights on the locus of knowledge integration are added. While prior studies mostly examined individual, group, and organizational-level knowledge integration in isolation, this master's thesis adopts a multi-level perspective on knowledge integration (Enberg et al., 2006) and shows how individual-level and group-level knowledge integration practices interact and how the locus of knowledge integration changes as a reaction to uncertainty. Third, the model developed in this master's thesis enriches our knowledge about the factors that influence knowledge integration practices with a team internal perspective that prior research in the field has neglected. While breakdowns (Lok & Rond, 2013, p. 186) in the knowledge integration process are proposed to be triggered by epistemic uncertainty and lead to temporary intensifications of collaboration in integrating knowledge (Mengis et al., 2018), the present thesis indicates that breakdowns in knowledge integration may also be triggered by smaller events, like conflicts, albeit having different consequences. In this regard, the present thesis suggests that disruptions may lead to temporary changes not only in the nature of collaboration but also in the characteristics of coordination. The central practical implication that arises from this master's thesis is that effectiveness and efficiency of the knowledge integration process can be influenced by actively managing the internal factors that tend to erode the effects of support mechanisms. However, the data also suggest that the agile product development methodology may only be appropriate in uncertain and novel contexts, in concept phases, and other phases were close coordination and collaboration are necessary. In rather routine projects of low innovativeness, in which interdependencies are low, the agile project structure could tie up too many resources.

2. Theoretical background

2.1. Organizational learning and knowledge integration

In contemporary literature on organizational learning, the change or increase in organizational knowledge occupies a central position (Schreyögg & Eberl, 1998, p. 519). An organization learns when the knowledge of its individual members is integrated into new organizational knowledge or through the recombination of existing knowledge (Kieser & Koch, 2008, p. 329). Especially, innovation and development projects demand the combination of a broad range of technical and functional knowledge to create new organizational knowledge in the form of new products or processes (Grant, 1996, p. 378). Emphasizing the significance of knowledge integration, Iansiti and Clark (1994, p. 557) propose that

> "[t]he capacity to integrate diverse knowledge bases is the foundation of knowledge building in an organization, and is therefore a critical driver of dynamic performance."

Leonard-Barton (1995, p. 64) suggests the locus of new knowledge to lie at the boundaries between specializations and their respective mindsets, implying the significant role of effective cross-boundary or cross-functional coordination for enabling the creation of competitive advantage (Carlile, 2004, p. 555). However, the creation of new organizational knowledge through integrating knowledge from diverse sources has been representing a core challenge for organizations ever since (Carlile & Rebentisch, 2003, p. 1181). Thus, the integration of individual-level knowledge into organizational knowledge represents one of the key problems dealt with in organizational learning research.

Knowledge comprises information on the one hand, and know-how on the other (Kogut & Zander, 1992, p. 386). Information, i.e. knowing what something means, includes facts, basic statements and symbols that are easy to transmit (J. S. Brown & Duguid, 1998, p. 91; Kogut & Zander, 1992, p. 386). Know-how is defined as "the accumulated skill or expertise which allows one to do something smoothly and efficiently" (Hippel, 1988; cf. Kogut & Zander, 1992, p. 386). In other words, know-how is the ability to convert information into required actions (J. S. Brown & Duguid, 1998, p. 95). Organizational knowledge may then be seen as "the sum of individual knowledge used in the value creation process and the knowledge embedded in collective action" (Schüppel, Müller-Stewens, & Gomez, 1998, p. 227). In the organizational learning literature there are various, sometimes contradicting ideas about how the specialized knowledge of individuals can be successfully integrated into organizational knowledge. The different concepts can be assigned to two perspectives, the "cross-learning" perspective and the specialization perspective (Grunwald, 2003, p. 3). The two views differ essentially in the extent to which they demand that knowledge has to be exchanged between organizational members to create a basis for integrating the knowledge of individual organizational members.

2.1.1. The cross-learning perspective

The cross-learning approach to integrating knowledge across domains of expertise suggests that for organizational learning to occur, knowledge needs to be transferred between specialists and combined in their individual brains (Kieser & Koch, 2008, p. 331). Among the first to propose this need for intensive cross-learning between specialists were Argyris and Schön (1978). The authors conceptualize organizational learning processes from a cognitive-theoretical perspective and assume that individual members of an organization develop to a certain extent common basic assumptions that manifest themselves in mostly unconscious organizational theories of action and are expressed in the actions of the organization. According to the authors, organizational learning means a change in collective theories of action. Argyris and Schön (1978, p. 17) argue that the pre-condition for successful knowledge recombination and creation is the development of shared "organizational maps", which is achieved through extensive knowledge transfer between individuals. Similarly, in their theory of organizational knowledge creation, Nonaka and Takeuchi (1995, p. 58) draw attention to the differences between the syntactic and semantic aspects (i.e. volume vs. meaning) of information. The authors emphasize that knowledge, like information, is about meaning, highlighting its context-specific and relational nature (Nonaka & Takeuchi, 1995, p. 58). Nonaka (1994, p. 24) emphasizes that through processes of socialization, teams need to form a "common base of understanding" or a "shared implicit perspective" to enable the continuous, time-consuming dialogues necessary for externalization, the critical learning process that involves transforming tacit into explicit knowledge that is accessible for the other members of an organization. In another approach, Kim (1993) proposes that individual and organizational learning are linked through mental models, defined as the thought constructs that influence individual and organizational actions. The integration of individual knowledge in organizational knowledge in this perspective is aided by shared mental models. According to Kim (1993), the vast majority of organizational knowledge (i.e. know-how and know-why) is stored in these shared mental models that are in turn deposited in the heads of the individual members of the organization (Kim, 1993, p. 44).

Research in the cross-learning paradigm concentrating on innovation in organizations especially points out the importance of a common base of understanding in product and process development, indicated by the holistic organizational learning concepts described above. Scholars in this field argue, that difficulties in knowledge transfer arise due to differences in the "thought worlds" of specialists (Dougherty, 1992, p. 182) and a lack of "common ground" among individuals of different departments (Bechky, 2003, p. 326). Research dealing with communities-of-practice points to the strong influence of a community's culture on knowledge sharing and underlines the connection of knowledge to the context in which it is learned (J. S. Brown & Duguid, 1991, p. 48; Lave & Wenger, 1991). It follows from this view that knowledge is assumed to be "largely tacit, situated, and experiential, and not easily articulated or codified" (Kellogg, Orlikowski, & Yates, 2006, p. 24). Dougherty (1992, p. 182) suggests that members of cross-functional teams representing different departments understand and interpret tasks or problems to be solved in different ways, due to their differing "thought worlds". Differences in the "fund of knowledge" (i.e. what is known) and the "system of meaning" (i.e. how do people know) of these thought worlds, lead to difficulties in sharing knowledge across departmental boundaries (Dougherty, 1992, p. 182). Similarly, Cronin and Weingart (2007, p. 763) argue that information sharing in functionally diverse teams might be impeded because of team members' differing problem representations stemming from the differences in the knowledge they hold. In creating di-

verging perceptions about how a problem should be tackled, these representational gaps complicate coordination between teammates (Cronin & Weingart, 2007, p. 762). Building on the work of Dougherty (1992), Boland and Tenkasi (1995, p. 358) argue that in order to integrate knowledge, organizational members need to engage in a process of perspective taking in which "the unique thought worlds of different communities of knowing are made visible and accessible to others". To overcome barriers to knowledge integration, cross-learning proponents basically suggest that individuals need to "identify, elaborate, and then explicitly confront the differences and dependencies across the knowledge boundaries" (Majchrzak et al., 2012, p. 951). Carlile (2002, 2004) distinguishes among three progressively complex types of knowledge boundaries that may occur between functionally diverse departments, presenting barriers to effective knowledge transfer: a syntactic or information-processing boundary that arises in the absence of a common lexicon, a semantic or interpretive boundary caused by inconsistencies in meanings, and a pragmatic or political boundary resulting from diverging interests. Carlile (2004, p. 556) argues that with increasing levels of difference, dependence and novelty of knowledge in a development project, the complexity of knowledge boundaries rises, posing new demands on the effective management of knowledge across a boundary.

A syntactic or information-processing boundary may cause a breakdown in knowledge transfer triggered by the absence of a shared syntax, i.e. a common lexicon, and the resulting mismatches in codes, routines, protocols, and other means of expression (Carlile, 2002, p. 443, Carlile, 2004, p. 558; Kellogg et al., 2006, p. 23). This boundary is theoretically grounded in the mathematical theory of communication (Shannon and Weaver (1949)) and the information-processing perspective on boundaries in organization theory (Galbraith, 1973; Lawrence & Lorsch, 1967), which basically assumes that knowledge is "external, explicit, and capable of being codified, captured, stored, retrieved, and transferred across people and contexts" (Kellogg et al., 2006, p. 24). This perspective holds that as soon as a syntax is shared among different parties, information can be processed, and knowledge can be transferred (Carlile, 2004, p. 558). Knowledge transfer in this view may be enabled by the development of information artifacts, such as standards, repositories, and specifications, that assist in communication across specialties under uncertainty (Kellogg et al., 2006, p. 23). A shared and stable syntax is suggested to be efficient, as specifications and agreements about knowledge differences and dependencies have been made in advance (Carlile, 2002, p. 453). Cross-specialty knowledge sharing in development projects may also be facilitated through actively involving individuals from multiple disciplines from start to finish (Lawrence & Lorsch, 1969; cf. Kellogg et al., 2006, p. 23)). Further, organizational members may take the roles of "technological gatekeepers" (Allen, 1970, p. 16) or "liaison-engineers" (K. B. Clark & Fujimoto, 1991, p. 103) installed to link different departments or communities with one another, thereby facilitating the flow of information and knowledge across boundaries.

A fundamental proposition of the information-processing view is that increasing levels of task uncertainty demand decision makers to process a higher amount of information. To be able to cope with the increasing information-processing demands, organizations need to adopt integrating mechanisms, like rules and programs, hierarchy, or goals, to increase their information-processing capabilities (Galbraith, 1974, pp. 28–29). Product development research in this tradition suggests the use of team-based structures, intensive communication, and information sharing true to the motto "more is better" to respond to uncertainty (Carlile, 2002, p. 444). However, some scholars critically note that information-processing or knowledge transfer frameworks may only offer satisfactory explanations in stable conditions that enable the development of a common lexicon or shared language between groups (e.g. Bechky, 2003, p. 313; Carlile & Rebentisch, 2003, p. 1182). For example, Carlile and Rebentisch (2003, p. 1182) argue that this simple view on knowledge transfer is not adequate to handle the complexity and ambiguity of knowledge integration activities inherent in contemporary organizations. Further, Bechky (2003, p. 313) claims that the universality of meaning and the homogeneity of context implied by simple knowledge transfer, do not mirror reality. Thus, Carlile (2004, p. 558) proposes that a syntactical boundary becomes a semantic boundary when novelty arises and the existing lexicon is no longer sufficient to clarify the newly emerging differences and dependencies.

Semantic or interpretive boundaries arise as a result of ambiguity in meaning (Carlile, 2004, p. 558). The interpretive or semantic approach to boundary spanning highlights that despite the presence of a common language, individual interpretations often differ, making communication and teamwork problematic (Carlile, 2002, p. 444). According to the interpretive perspective, just processing information is insufficient to overcome differences in meaning. Rather individuals need to learn about and understand the differences, dependencies and boundaries between each other's knowledge to enable knowledge sharing across a semantic barrier (Carlile, 2002, p. 444; Majchrzak et al., 2012, p. 952). Thus, scholars argue that overcoming semantic boundaries and enabling knowledge sharing necessitates the development of a "common meaning" (Carlile, 2004, p. 555).

To address the interpretive differences across boundaries and to arrive at a common meaning, Carlile (2004, p. 558) suggests knowledge translation as central practice. To do so, scholars stress the importance of cross-functional teams, colocation, and the utilization of shared practices (Carlile, 2004, p. 558). Further, insights from the communities-of-practice literature (J. S. Brown & Duguid, 1991; Lave & Wenger, 1991) imply that shared meanings can be developed through participation in similar activities (Carlile, 2004, p. 558). J. S. Brown and Duguid (1998, p. 103) also highlight the role of individuals as "organizational translators" and "knowledge brokers" in encouraging the movement of knowledge between different communities-of-practice. While translators are in place to "frame the interests of

one community in terms of another community's perspective" (p. 103) like mediators, brokers truly participate in several communities-of-practice allowing them to "broker" knowledge between the domains (J. S. Brown & Duguid, 1998, p. 103). For example, in an ethnographic study of the product design firm IDEO, Hargadon and Sutton (1997, p. 716) showed how the designers at the firm acted as technology brokers by connecting current design problems with existing solutions from other domains or industries to create new products. Boland and Tenkasi (1995, p. 362) emphasize the fundamental role of boundary objects for the process of perspective taking, as they enable individuals to bring their distinctive viewpoints into dialogue. Boundary objects can be physical objects like documents, protocols, concepts and prototypes, but also technologies or procedures that are jointly used by the communities but may be perceived of in distinct ways by the parties involved. These objects assist in clarifying commonalities and differences in the practices, attitudes, and world views of the differing knowledge domains and facilitate the development of a common understanding (J. S. Brown & Duguid, 1998, p. 104). However, in some cases novelty might generate differences in the interests of different actors, impeding their ability to share and assess knowledge (Carlile, 2004, p. 560). Under these circumstances, translating different meanings will not prove sufficient. Instead negotiating interests and transforming knowledge between actors become central processes to enable knowledge transfer, prompting the transition of a semantic to a pragmatic boundary (Carlile, 2004, p. 559).

As already implied, a pragmatic or political boundary concerns differences in interests, goals, practices, and other commonly held community-specific aspects of diverse knowledge domains (Carlile, 2004, p. 559). Research dealing with these pragmatic differences stresses the importance of understanding the consequences that differences and dependencies in knowledge across boundaries bring about (Carlile, 2002, p. 445). In the pragmatic view, knowledge is assumed to be localized, embedded, and invested in practice, recognizing the worth of knowledge and that it is "at stake" for those who created it (Carlile, 2004, p. 559). Carlile (2002, p. 445) emphasizes the complexity of overcoming a pragmatic boundary in outlining that

> "[t]he cross-boundary challenge is not just that communication is hard, but that to resolve the negative consequences by the individuals from each function they have to be willing to alter their own knowledge, but also be capable of influencing or transforming the knowledge used by the other function."

Thus, reducing differences in interests necessitates the joint transformation of existing domain-specific as well as common knowledge into new knowledge (Carlile, 2004, p. 559). However, the process of knowledge transformation is challenging, as it demands the actors involved to invest in relationship building and make trade-offs in practices, interests, and jurisdictions (Kellogg et al., 2006, p. 24). To support the negotiation of interests and the transformation of knowledge, scholars stress the importance of team structures and shared artefacts, methods, and practices that provide a common ground for sharing and assessing knowledge (Bechky, 2003, p. 326). While boundary objects may enable knowledge transfer across all three types of boundaries, they have been found to be particularly useful in overcoming pragmatic barriers in product development settings (Carlile, 2004, p. 559). According to Carlile (2002, p. 453) effective boundary objects need to: (1) establish a shared language, (2) provide individuals with a way to learn about the differences and dependencies of knowledge across boundaries, (3) enable processes of knowledge transformation in which individuals can alter their domain-specific knowledge into cooperatively created "common knowledge" (Carlile, 2004, p. 559). In studying misunderstandings between engineers, technicians, and assemblers on a production floor, Bechky (2003, p. 312) demonstrated how the cocreation of such "common ground" transformed individuals' perception of the product and the production process leading to a deeper understanding of the product and its problem areas.

However, the central assumption in cross-learning approaches that intensive knowledge exchange between actors is the prerequisite for integrating the diverse knowledge bases of specialists has been criticized by some authors. These scholars argue that the idea that specialists need to acquire the knowledge of other specialists to achieve integration would pose extraordinary challenges for the members of the organization in light of their limited cognitive capacities and therefore seems impractical (Kieser, 2001, p. 244). Thus, they cast doubt on the effectiveness of cross-learning as a mechanism to integrate knowledge, even if transfer is supported by boundary objects or boundary spanners (Kieser & Koch, 2008, p. 332). For example, Demsetz (1991) argues that the need for intensive learning between specialists in an organization would undermine the advantages of the division of labor.

> "Although knowledge can be learned more effectively in a specialized fashion, its use to achieve high living standards requires that a specialist somehow uses the knowledge of other specialists. This cannot be done only by learning what others know, for that would undermine gains from specialized learning." (Demsetz, 1991, p. 172)

Moreover, intensive cross-learning between specialists is associated with significantly high resource and time expenses and assumed to be an ineffective means of integrating diverse knowledge bases (Enberg et al., 2006, p. 145; Majchrzak et al., 2012, p. 951). Thus, scholars argue that there must be mechanisms "that bring about the recombination of knowledge but do not strongly depend on cross-learning and human cognitive abilities" (Kieser & Koch, 2008, p. 332). The approaches turned to next, show how such mechanisms may enable learning processes while maintaining specialization and do not require an in-depth knowledge transfer. Among

them are experience-based learning concepts in the tradition of the behavioral theory of the firm (March & Olsen, 1975) and the knowledge-based view (Grant, 1996).

2.1.2. The specialization perspective

The organizational learning concepts rooted in the behavioral theory of the firm (Cyert & March, 1963), assume that rules and routines are the starting point for and the outcome of learning processes (Kieser et al., 2001, p. 599). The behavioral theory of the firm (Cyert & March, 1963) portrays organizations as goal-oriented and rule-based systems that learn from experience. In this view, organizations learn by drawing conclusions from experience and appropriately adapting their standard operating rules to the changing environment (Cyert & March, 1992, p. 120). Grounded in these assumptions, March and Olsen (1975, pp. 148–150) propose a learning cycle with four ideal phases describing how experience-based learning transforms individual actions into organizational actions: (1) individual actions are based on individual perception and preferences, (2) these individual actions lead to organizational actions, (3) the organizational actions trigger certain environmental reactions, (4) which in turn influence individual perceptions and preferences. However, according to March and Olsen (1975, p. 158) certain barriers to learning may disrupt this cycle, thus making it incomplete. These are: (1) role-constrained experiential learning, in which individual learning is hampered by restrictive role-definitions and detailed standard operating procedures, (2) audience experiential learning, pointing to the limited influence of individuals in changing organizational actions, (3) superstitious experiential learning, which arises when organizational members misleadingly attribute a rule-based change in certain behaviors to a change in the environment, and (4) experiential learning under ambiguity, in which organizational members cannot draw clear conclusions from environmental reactions due to ambiguity.

A basic assumption in concepts rooted in the behavioral theory of the firm, is that organizations learn through experience and that learning changes their behavior. As opposed to the cross-learning approach, this view postulates that the outcomes of organizational learning are stored in artefacts, i.e. standard operating rules, and not in individual employees (Kieser et al., 2001, p. 599). In informing organizational members how to handle and process information, make decisions, and evaluate the results of decisions in particular situations, standard operating procedures serve as the organization's primary memory, enabling the transfer of past learning (Cyert & March, 1992, pp. 123–127). Accordingly, rules and standards incorporate solutions to organizational problems, thereby complementing specialization as a mechanism that enables cooperation of organizational members despite their limited rationality and cognitive capacity (Kieser et al., 2001, p. 600; Kieser & Koch, 2008, p. 331).

The knowledge-based view (KBV), proposes that the primary role of the firm is the integration of individuals' specialist knowledge to create organizational capabilities (Grant, 1996, p. 375). Knowledge is supposed to be heterogeneously distributed among individual specialists and functional departments in an organization, due to individuals' bounded rationality and limited cognitive capacity that restricts the infinite absorption of knowledge. A fundamental task is therefore the coordination of diverse specialists' efforts to economize on specialization and achieve organizational goals (Grant, 1996, p. 113). From the perspective of the knowledge-based view, the coordination and integration of the knowledge of different domains does not require extensive knowledge sharing (Grant, 1996, p. 114). Quite contrarily, Grant (1996, p. 114) claims that

> "[t]ransferring is not an efficient approach to integrating knowledge. If production requires the integration of many people's specialist knowledge, the key to efficiency is to achieve effective integration while minimizing knowledge transfer through cross-learning by organizational members."

In doing so, Grant (1996) formulates quite clear requirements for the mechanisms of knowledge integration, rejecting the notion of intensive cross-learning and instead emphasizing the reduction of knowledge transfer. According to Grant (1996, p. 114), there are four mechanisms that facilitate the integration of specialized knowledge into organizational knowledge: (1) rules and directives, (2) sequencing, (3) routines and (4) problem-solving and decision-making in groups. Rules and directives, involving plans, lists, forecasts, guidelines, and procedures, enable the conversion of implicit knowledge into explicit knowledge. They promote knowledge integration by coordinating the interactions between specialists through the use of common standards and significantly reduce the need for shared knowledge (Grant, 1996, p. 114). Sequencing encompasses the arrangement of activities in a chronological sequence, so that various specialists may complete their diverse subtasks independently (Grant, 1996, p. 115). The modularization of tasks and the accompanied reduction in communication and coordination efforts are particularly important for complex projects that demand for broad-scope knowledge integration (Grant, 1996, p. 381). Organizational routines also provide a mechanism for integrating knowledge. In generating routines, specialists develop sequential patterns of interaction, which allow for the integration of specialist knowledge in absence of verbal communication (Grant, 1996, p. 379). Group problem-solving and decision-making are more personal and communication-intensive forms of integration that are used for unusual, complex and important tasks, in situations in which rules, instructions and routines reach their limits (Grant, 1996, p. 115). According to Grant (1996, p. 115) knowledge integration should be carried out using the first three mechanisms, if possible, to avoid extensive knowledge transfer and the associated costs.

While Grant (1996, p. 114) argues, that knowledge transfer through cross-learning in organizations should be minimized, he also points out that for knowledge to be integrated, members of an organization need to dispose of a

certain level of common knowledge, representing the intersection of their individual knowledge bases (Grant, 1996, p. 115). It follows that, in innovation projects, organization members need at least a rough understanding of the overall process or product in order to better coordinate their work with others. Grant (1996, p. 116) outlines five types of common knowledge: (1) a common language, which allows an unambiguous understanding between departments and specialists at the organizational and project level, (2) other forms of symbolic communication that complement the verbal aspects of language, (3) a basic stock of common specialist knowledge, (4) shared interpretations that facilitate the interdisciplinary transfer of tacit knowledge, and (5) recognition of individual knowledge domains, involving knowledge about who knows what in the organization or project. However, how exactly individual knowledge integration comes about in the knowledge-based view proposed by Grant (1996) remains unclear, as his statements are rather abstract.

2.2. State of the art in empirical research

A growing body of empirical work on knowledge integration in general and in innovation projects in particular indicates that deep-level knowledge sharing as demanded by cross-learning approaches is not always necessary to enable knowledge integration (Majchrzak et al., 2012, p. 954). Already, Donnellon, Gray, and Bougon (1986, p. 43) showed that organized action among organizational members can happen in absence of shared interpretations. The authors observed that the creation of "equifinal meaning" through communication enabled coordinated action. Further evidence comes from Galison (2000, p. 46), who found that physicists from different subcultures (i.e. theorists, experimentalists, and engineers) advancing divergent viewpoints, were able to align their activities without the development of shared interpretations, identities and interests. Galison (2000, p. 46) uses the metaphor of a "trading zone" to describe an "intermediate domain" in which activities may be coordinated locally, even if the broader meanings of different subcultures collide.

Similarly, studies on R&D projects and product development imply that extensive cross-learning is not a precondition for successful knowledge integration and innovative performance (e.g. Enberg et al., 2006; Faraj & Xiao, 2006; Majchrzak et al., 2012; Schmickl & Kieser, 2008). For example, in their study of an interactive marketing organization, Kellogg et al. (2006, p. 40) found that coordination within projects can be achieved without building "deep commitments to shared meanings or transformed knowledge". Instead, project team members enacted "trading zones" (Galison, 2000) by agreeing on the general procedures of knowledge exchange, i.e. the technology-based coordination practices, which allowed them to interact across boundaries even if their local understandings of a task diverged (Kellogg et al., 2006, p. 42). Members of different communities in the project integrated their diverse knowledge by sharing their contributions in a "common digital space", in the form of e-mails, PowerPoint or Word documents, thereby making their work mutually visible and legible, which allowed for ongoing adjustments and alignment of the diverse contributions (Kellogg et al., 2006, p. 40). Similarly, Enberg (2012) found that in coopetitive R&D projects knowledge integration was built on a shared understanding of the process and not the content of project work. Planning and process specifications, and presentation genres were found to enable knowledge integration. While these mechanisms aided the processes for integrating knowledge, they simultaneously constrained the breadth of knowledge to be exchanged and provided a structure for collaboration and face-to-face discussions and thus reduced knowledge transfer among specialists (Enberg (2012, p. 771)). In studying successful innovation teams in an electrotechnical company, Schmickl and Kieser (2008, p. 487) also only found limited evidence for deep-knowledge sharing. Rather, team members exchanged "broad" and "rough" knowledge to integrate their diverse viewpoints. The exchange of "narrow" and "detailed" knowledge happened selectively on occasion through a kind of question and answer game (Schmickl & Kieser, 2008, p. 487). Schmickl and Kieser (2008, p. 488) identified modularization, prototyping and transactive memory as integration mechanisms that, in combination, substitute for cross-learning in product development. Modularization refers to breaking down products or processes into simpler components and may reduce knowledge transfer by allowing specialists to work independently on their components to a certain extent (Schmickl & Kieser, 2008, p. 476). Prototyping may be defined as iterative trial and error process, in which team members engage to align their diverse efforts. Knowledge transfer may be reduced, because prototyping directs attention to identifying and explaining problems between components, thus narrowing the scope of knowledge that needs to be shared. Transactive memory, i.e. knowledge about who knows what, helps team members to readily localize specialists with relevant knowledge, thus curtailing search processes and reducing the need for knowledge transfer (Schmickl & Kieser, 2008, p. 477). Likewise, Enberg et al. (2006) showed how the reliance on certain mechanisms and practices allowed team members in a development project in the manufacturing industry to work on their tasks in isolation "without a lot of effort devoted to knowledge sharing" (Enberg et al., 2006, p. 158). Knowledge integration in the stacker project under study was achieved through ad hoc problem-solving, experience rather than knowledge sharing, and "individuals' idiosyncratic representations of the stacker artefact" (Enberg et al., 2006, p. 158). In this regard, Enberg et al. (2006, p. 157) highlight the complementary role of formal meetings in achieving coordination among functionally diverse team members. In the project they studied, regular meetings strengthened the commitment of team members to integrate their diverse knowledge bases by aiding the development of a common goal and a general sense of being a team. Furthermore, the focus on experience sharing, rather than knowledge exchange, in the time-limited meetings aligned team members' mutual expec-

tations of task completion, thereby facilitating coordinated action (Enberg et al., 2006, p. 157). Similarly, Majchrzak et al. (2012) showed how brainstorming workshops, strategic planning meetings, and other face-to-face meetings provided an arena for the members of cross-functional teams to integrate their diverse knowledge bases. The team members engaged in five dialogic practices that allowed them to cocreate a solution without emphasizing the differences among their knowledge domains despite task novelty (Majchrzak et al., 2012, p. 958).

Thus far, contemporary empirical research seems to agree that knowledge integration may involve merely mentioning and demonstrating knowledge, rather than a "deep" sharing of interpretations and interests (Mengis et al., 2018, p. 597). However, extant research also suggests that the intensity of knowledge sharing in teams depends on the novelty and uncertainty they face. For example, Schmickl and Kieser (2008, p. 485) found that the more radical the innovation, the more knowledge was exchanged between project members (Schmickl & Kieser, 2008, p. 485). Furthermore, research that frames knowledge integration as a process rather than an outcome implies that the process of integrating knowledge may change over time (Mengis et al., 2018, p. 598). For example, Bruns (2013, p. 62) discovered that coordination across domains of expertise in a group of scientists was achieved through switching between the collaborative practices of counterprojection and alignment when the scientists were working alone, and the more dialogic coordination practices of joint assessment and consultation when they worked together. In the trauma care context, Faraj and Xiao (2006, pp. 1164–1165) observed that as unexpected events occurred, trauma teams sometimes had to abandon established treatment protocols and relied more on dialogic coordination, involving joint sensemaking, to arrive at a new collective understanding of the patient. Similarly, Mengis et al. (2018) suggest that knowledge integration is not a consistent process, but rather requires alternations between different coordination practices over time. In their study of collaboration efforts of scientists involved in the development of a highly novel bioreactor, they found that particularly in cases of "epistemic breakdowns", i.e. disruptive events that erode extant understandings of a problem, scientists changed their coordination practices. When such breakdowns occur, the scientists changed from a coordination mode of "working together alone" (Bruns, 2013; Enberg et al., 2006) to a more intensely collaborative one that focused on dialogically drawing distinctions to expand collective knowledge. As soon as the scientists had drawn new distinctions they established a revised division of labor that again shifted their focus towards coordinating their work, albeit in a more political fashion centered on the alignment of expectations and obligations (Mengis et al., 2018, p. 607).

Taken together, the presented findings imply that extensive deep-level knowledge sharing is not key to successful knowledge integration, thereby contradicting the central conjecture of the cross-learning approach. Rather, extant empirical work on knowledge integration seems to comply with the specialization perspective, in particular the knowledge-based view, suggesting that certain practices and structural mechanisms reduce the need for knowledge sharing. However, recent studies on product development projects suggest that the need for and the engaging in knowledge sharing are dependent on the level of task novelty or innovativeness of the product or project (e.g. Schmickl & Kieser, 2008). Moreover, studies dealing with the collaboration of diversely specialized scientists in highly novel and uncertain settings, point to the processual nature of knowledge integration that implies the variation of coordination and collaboration practices over time. While most of the studies on cross-functional teams in new product (e.g. Schmickl & Kieser, 2008) or new process development (e.g. Majchrzak et al., 2012) consider the overall level of uncertainty and its impact on knowledge integration, they do not show how knowledge integration mechanisms and practices change over time within the course of a project. For example, the concept phase in new product development may raise other coordination demands than the implementation phase in both radical and incremental innovations. Furthermore, unexpected problems or changes in customer demand may trigger the emergence of coordination mechanisms other than those currently in place (Grant, 1996, p. 113). Finally, despite prior research implied the need for of a multi-level perspective on knowledge integration (Enberg et al., 2006), the interplay of individual-level and group-level knowledge integration practices as well as the changes in the primary locus of knowledge integration within the course of a project have not yet received adequate attention in empirical research on knowledge integration in new product development teams.

3. Methods

3.1. Research design

The starting point for this master's thesis was my curiosity about the ubiquitous organizational agility hype that has been spreading across various industries and affecting project work in numerous areas of application. An initial search of the EBSCOhost database "Business Source Premier" revealed a lack of scientific research on agile methods in the leading management journals, and a general scarcity of studies outside the software development context. As mentioned in the introduction, popular scientific papers and books often associate the agile methodology with increased team performance and velocity and attribute a superiority over classic project management methods to the agile way of working. However, empirical support for these claims is missing, which was the decisive factor to focus my study on the phenomenon of (successful) agile teamwork in product development outside of the software industry. A suitable manufacturing company, which allowed the investigation of two of their agile development teams, was found through my personal network. A first meeting with CEO, Head of Innovation and Head of HR was held in July 2019 to clarify mutual expectations and to agree on the anticipated result of the master's thesis. As

a result, the initial phase of the research project was guided by the following question: "What are the success factors of agile teamwork in product development projects in the manufacturing industry?".

Collaboration and coordination in cross-functional or agile teams are complex phenomena. Therefore, researchers need to undertake a deep dive into individuals' attitudes, motives, and perceptions to be able to gain an understanding about the processes lying beneath individual and group behavior that are associated with the creation of new products and services. Qualitative methods offer the opportunity to explore the complexity of human behavior by allowing respondents to share their experiences, perceptions, and feelings about a certain topic with the researcher in their own words (Berg, 2001, p. 7). Furthermore, the lack of research on the success factors of agile teamwork calls for an inductive, interpretive approach that enables the elucidation of factors that affect the realization of agile product development projects and that have not been previously discovered. Thus, a grounded theory methodology (Glaser & Strauss, 1967) was applied. More precisely, the research design was set up adhering to the principles of the Gioia Methodology (Gioia et al., 2013).

The grounded theory method was introduced by Glaser and Strauss (1967) in their book "The Discovery of Grounded Theory". The methodology encompasses an inductive and comparative approach to research with the ultimate aim of building theory embedded in empirical data. Within this approach, data collection and analysis happen simultaneously rather than sequentially, thereby mutually influencing each other. Throughout the project, researchers iteratively process back and forth between empirical data and the emerging analysis (Bryant & Charmaz, 2007, p. 1). As opposed to hypothesis-based methods, the starting point for grounded theory research resides in empirical data and not in the extant literature. Thus, researchers should not start by formulating hypotheses to be tested, but rather by gathering data relevant to a phenomenon of interest that form the foundation for developing the framework of the research project (Bryant & Charmaz, 2007, p. 126). By applying theoretical sampling, i.e. the selection of a case or a sample against the background of theoretical considerations, data collection gets refined and more focused over time, which allows for an increasingly focused theoretical analysis (Bryant & Charmaz, 2007, p. 1; Flick, 2009, p. 432). Data is collected and analyzed until theoretical saturation is reached, which means that no new insights can be obtained with additional data (Flick, 2009, p. 436). Features like the proximity to the data or the empirical referents, the structure provided for analyzing complex social phenomena, and the ability of developing meaningful practical theories have been contributing to the popularity of the grounded theory methodology among researchers (Bryman, 2000, p. 84). The approach has been offering profound contextual theoretical accounts of organizational phenomena (Gioia et al., 2013, p. 16). However, despite its advantages the approach is not free of criticism. Some scholars claim that inductive methods are inappropriate to achieve the high criteria that apply to validating scientific progress (Gioia et al., 2013, p. 17). Accordingly, qualitative researchers are regularly accused of reluctance to incorporate theoretical aspects into their studies (Bryman, 2000, p. 85). Furthermore, dealing with the flood of data associated with grounded theory methods, disregarding extant theories relating to the topic of interest, and the selection of a research site constitute severe practical challenges for this kind of investigation (Bryman, 2000, p. 87).

To counter the allegations of inappropriateness and to increase practicability of grounded theory, Gioia and his colleagues (S. M. Clark, Gioia, Ketchen, & Thomas, 2010; Corley & Gioia, 2004; Gioia & Chittipeddi, 1991; Gioia, Price, Hamilton, & Thomas, 2010; Harrison & Corley, 2011; Nag, Corley, & Gioia, 2007; Nag & Gioia, 2012) have been developing and successively refining a holistic approach to inductive concept development, which is intended to ensure highly qualitative scientific rigor, and which is becoming increasingly popular among organizational researchers. The methodology is centered around two basic assumptions: (1) the organizational world is socially constructed, and (2) organization members are "knowledgeable agents", meaning that they have an idea of what is going on around them and can provide qualified information about their thoughts, intentions and actions. Accordingly, this approach attaches great importance to the interpretations of the informants right from the start of data collection and analysis, creating fruitful opportunities for concept discovery rather than confirmation. Furthermore, the method's developers assume that scientists are also well-informed and therefore able to recognize patterns, relationships, and emerging concepts in collected data and place them in a theoretical context (Gioia et al., 2013, p. 17). Gioia et al. (2013, p. 16) emphasize that, in their view, "concepts are precursors to constructs in making sense of organizational worlds", by which they mean that for the purpose of theory building, researchers first of all need to discover relevant concepts that can subsequently direct the formation and validation of theoretical constructs (Gioia et al., 2013, p. 16). While research design and data collection within the Gioia Methodology are similar to traditional grounded theory approaches, data analysis and the articulation of grounded theory are carried out distinctively (Gioia et al., 2013, p. 26). In the following, I will first shortly describe the research setting before providing detailed accounts of my approach to data collection and analysis.

3.2. The case of A-Machining

As already implied, for my research I got access to two agile product development teams of an Austrian company, which produces and sells special machinery and associated spare parts. For the remainder of this thesis, I will call the company A-Machining. In the fiscal year 2018/19 the company had sales of 382 million Euro, 90 percent of which were from abroad. Currently the company employs approximately 1,900 people worldwide. Founded in the 19th century, the family-owned company can look back on a long success story.

For many years, A-Machining has been holding global market leadership in one of its segments and is recognized as innovation leader. However, through this rather stable position, negative consequences have evolved over time. Silos had formed around the individual departments within the company, which made it difficult to exchange information with other teams and areas of expertise. This negative effect is reinforced by the spatial distance between some departments. For example, while the mechanical engineers work in the main building, the departments of mechatronics and testing are situated in another building across the street. Three years ago, the culture of conversation was shaped by disputes about resources and self-serving behavior affecting innovative capacity and efficiency. In order to defend its global market position and to cope with the dynamic corporate environment in the future, it was time for the company to change the culture of collaboration. Therefore, A-Machining decided to restructure internal collaboration by tearing down the departmental silos and improving communication with the ultimate aim to increase development efficiency and shorten time-to-market. In November 2017 the machine constructor introduced AGILE as the new method for structuring its new product development projects. Good leadership with clear goals, autonomy and feedback, as well as good collaboration are the key characteristics of AGILE for the company. With the new method A-Machining aimed at overcoming department-centered thinking, motivating employees, coping with complexity and being able to plan the unknown. Accompanied by a group of consultants, two pilot projects were set up with the new structure and way of working. In advance, the employees were informed about the agile way of working in a day event. By the end of 2019 the company had ten agile projects with approximately 100 employees involved.

In the following, I want to give an overview of the key components and ceremonies of agile product development, as introduced by A-Machining, to offer a richer understanding of the comprehensive structure of such projects. The descriptions are derived from the book of Schröder (2017, pp. 44–77), which the company used as a guide for implementation. In addition, data from conversations and a PowerPoint document provided by the company, including the main building blocks of agile product development, were used to cover the adaptions of the methods in the company.

An agile team needs to cover the following three roles: (1) The Product Owner Team (POT), (2) the Work Team, and (3) the Agile Coach. The Product Owner Team comprises representatives from technology, the market, project management and production. The POT is in charge of the project plan. Their main duty lies in defining what has to be done and creating, maintaining and prioritizing the Product Backlog, i.e. the target specifications of the product. They are responsible for the economic success of the product and represent the interests of the customers in the team. The members of the Work Team originate from different departments of the company, such as mechanical engineering, test engineering, mechatronics, controlling and purchase. It is up to them to decide how to meet the requirements defined in the Product Backlog. They are responsible for the timely delivery and the quality of the product. The Agile Coach ensures compliance with the agile principles and procedures and moderates all agile ceremonies. Also, he or she shall protect the team from disruptions and remove any appearing obstacles and barriers.

In agile project management, the overall project plan gets divided into stages of three months – the closer the stage, the more detailed the plan. The stages in turn are divided into six sprints of 14 days each. This differentiation between rough and detailed planning allows the POT to deal flexibly with market changes and other uncertainties. Within one sprint the following agile ceremonies take place:

The Conclave – A new sprint starts with a planning meeting of the POT members. It is called Conclave, because the POT members need to agree unanimously on the plan for the next sprint. This meeting takes place in a 14-day-rhythm at the same time and at the same place. Its duration varies between 30 and 90 minutes depending on the phase of the project and the experience of the POT. A POT-Agile-Board, that typically consists of the four columns (1) Backlog (i.e. ToDo), (2) Work in Progress, (3) Done, and (4) Definition of Done, i.e. the specifications of a result and the prioritization of the desired outputs, helps the POT to structure and visualize the sprint plan. First, each member of the POT writes down the desired outcomes for the upcoming sprint on blue Post-Its and places them in the Backlog column. Importantly, the outcomes shall be measurable and precisely formulated and the descriptions shall concentrate on what to do and not how to do it. As the board shall be clearly arranged and easily comprehensible for the Work Team, the number of items should not exceed 15. Second, the representatives of technology, market, production and project management need to agree on a prioritization of the Backlog and arrange the items on the list according to their importance. This process is moderated by the Agile Coach, who closes the meeting by asking whether all participants believe that this Backlog will lead to a successful project. If the answer is yes, then the next ceremony can start.

The Sprint Planning – Directly after the Conclave, POT and Work Team meet to discuss the prepared Backlog list displayed on the POT-Agile-Board. Again, this meeting is moderated by the Agile Coach. In a first phase, the POT members present their expectations, and the Work Team members have the possibility to ask questions, resolve uncertainties or ambiguities, point to missing items and express doubts. The team members estimate time and effort needed to fulfil the requirements of every single item. If necessary, the blue Post-Its of the POT are corrected and changed or new items are added to the list. As a result, the original Product Backlog list is adapted to display and integrate the perspectives of both POT and Work Team. In a second phase, the Agile Coach asks the Work Team whether this workload can realistically be accomplished within two weeks. As the team members are usually involved in more than one project, they need to check their capacities for the upcoming weeks. In

the third phase, the Work Team communicates what is possible against the background of the updated Sprint Backlog and the team's capacity. By drawing a horizontal line with a yellow fine-liner on the POT-Agile-Board, the team indicates how many items can be achieved at the given capacity. The POT can react to this feedback by, for example, increasing capacities, moving items to the next sprint, or changing prioritization. The fourth phase is about confirming the final agreement on the Sprint Backlog. In a thumbs-up-ritual every member of POT and Work Team shows his or her commitment to the plan. Now, the POT leaves the meeting and in the fifth and final phase, the Work Team has time to work out how to best achieve the goals on the Sprint Backlog they committed themselves to. By using a Team-Agile-Board, they break down the requirements on the blue Post-Its into smaller activities and write them down on yellow Post-Its.

The Daily-Stand-up-Meeting - In this short daily team meeting in front of the Team-Agile-Board the members of the Work Team discuss barriers and challenges and try to solve any pending problems. Meeting duration is exactly 15 minutes to ensure efficiency. Devices, like an agile-clock displaying the laps of 15 minutes or a sandglass for managing the equally distributed time allotted for speaking, can be used to ensure compliance with the strict time constraint. If team members recognize a need to go deeper into a particular topic, they arrange informal, bilateral meetings outside the formal meeting structure wherein only those people, who are required for problem-solving, are involved. Especially in the introductory phase of agile project management, it can be useful to have the Agile Coach as a moderator in the Dailies. However, his or her presence is optional.

The Sprint Review (also DEMO, for demonstration) – After 14 days POT and Work Team meet for the Sprint Review. Depending on the project phase the review may last between one and two hours. In this meeting the team members present the results of the sprint to the POT for the first time. Thus, the moderation of the Agile Coach is an important factor. Visualization is key for an effective presentation. Therefore, a DEMO can also take place at a testing or production site including, for example, a prototype. However, usually the results are jointly prepared in a PowerPoint presentation with the use of pictures and descriptive language. A crucial part here is that the POT takes on its leadership function by showing real appreciation for the work done, thereby motivating the team. The results are either accepted by the POT and put in the "Done" column of the Sprint Board or remain on the board for revision in the next Conclave and Sprint Planning sessions.

The Retrospective (also RETRO) (30 min) – Directly after the Sprint Review, the team reflects on the last sprint in terms of teamwork, agile way of working and constraints in the project. This feedback session may be conceived as a regular lessons-learned workshop and represents an important means for resolving conflicts and continuous process improvements. Depending on the number of topics, this meeting may last about 30 minutes. However, it emerged from the interviews that the RETRO is hardly used. While the Work Team is busy with the Retrospective, the POT leaves for the Conclave, thereby starting the new sprint.

In the following paragraphs, the two pilot projects, which I re-named Project Colossus and Project Homestretch, will be shortly described. As of October 2019, Project Colossus had been running for five years. The project revolves around the fundamental revision of the machine manufacturer's flagship product, in whose segment the company is global market leader. It is a demanding and unusually large project for A-Machining, in which many different parts have to be precisely coordinated. Thus, in many ways, the company is breaking new ground with this project. The overarching aim of Project Colossus is to set an example with the new model. It should be innovative, differentiate itself from the competition with clear USPs, and strengthen the company's role as technology leader, which is associated with high pressure for success for the development team. Two years earlier, however, a direct benchmark test with the toughest rival in the product segment revealed that the product in development by far cannot compete with the competition. That was a devastating day for the development team. The market requirements for the product had changed and the product, as it was at that time, was not able to meet those expectations. As a consequence, top management decided to stop the project. To make a clear cut, all the prototypes were scrapped. In November 2017, Project Colossus was relaunched with the agile product development methodology. The team now comprises 23 members, including one Agile Coach and a Product Owner Team of four. The functional departments involved in the Work Team are mechanical engineering, mechatronics, testing, purchase, controlling, quality, and production. After an initial orientation phase, the team members soon accepted the new methods and exemplarily exercised self-organization. Thus, concerning compliance with the agile principles and methods, there was no need for the Agile Coach to intervene a lot. The development team started from scratch and had the opportunity to build the new product on the "green field". Notwithstanding the big change, motivation was high, and the team members had many innovative ideas, including real novelties in the market. The development time starting with the first line drawn in the concept phase and ending with the assembly of the first prototype was seven months – extraordinarily short for A-Machining. However, despite the good restart, the project team was faced with problems concerning the manufacturing costs of the product at the time the interviews were conducted. Consequently, many parts of the product would need to be reworked or sourced from other suppliers to be able to meet market prices. So far, three prototypes have been built in the course of the project and two more are planned.

Project Homestretch is about a program expansion in another product segment. The main requirement of this project is to develop a bigger version of a special machine including the corrections of reclamations in the existing product line and the integration of some additional features that mirror customer demands. In contrast to Project Colossus, the pressure to succeed for the project team and the desired

level of innovativeness is as high as in average projects at A-Machining. Project Homestretch comprises a rather big development team, with 17 team members in the beginning and 10 members in the final phase. Similar to Project Colossus, the functional departments involved in the Work Team are mechanical engineering, mechatronics, testing, purchase, controlling, quality, and production. The project had been running for one year when it was reorganized with the agile product development methodology. At that time, the concept phase was already completed, and the focus shifted to making the product ready for production, narrowing the corridor for subsequent changes. The introduction of the agile methodology was challenging, as the team members reacted rather cautiously to the considerable transformation of collaboration in the product development process. Especially in the initial phase, many interventions of the Agile Coach were necessary to ensure that the agile principles and methods were applied correctly and thoroughly by the team. However, within the course of the project no bigger problems appeared. At the time of the interviews, the project was nearly completed and therefore the meeting rhythm in the agile methodology was reduced.

3.3. Data collection

Especially through interviews researchers can access peoples' perceptions of certain events or experiences and can comprehend, how individuals make sense of their social world (Berg, 2001, p. 72). Semi-structured interviews form the core of the data collection strategy applied in studies using the Gioia Methodology (Gioia et al., 2013, p. 19). The degree of structure is often used as a means to classify research interviews in the literature (Qu & Dumay, 2011, p. 244). Most commonly, the following three types are distinguished: (1) structured, (2) unstructured and (3) semi-structured interviews. In a structured interview the questions and their sequence are predefined, ensuring consistency across all the interviews. Deviations from the interview script shall be avoided, which makes the process inflexible (Qu & Dumay, 2011, p. 244). Researchers, who utilize this technique, have already concrete ideas of what they want to find in the interviews (Berg, 2001, p. 69). Using this interviewing approach, researchers seek to minimize researcher bias and increase generalizability of their findings (Qu & Dumay, 2011, p. 244). A disadvantage is that structured interviews do not utilize the dialogical potentials for knowledge production that conversations hold and therefore only represent a passive picture of individuals' opinions and attitudes (Brinkmann, 2014, p. 286). Thus, structured interviews were considered inappropriate for this research project. The counterpart to the structured interview described above, are unstructured interviews. Researchers who apply this method, do not use a predefined set of questions but rather intuitively develop questions appropriate to the interviewee's reactions and statements in the interview situation (Berg, 2001, pp. 69–70), while at the same time keeping the central purpose of the research in mind (Qu & Dumay, 2011, p. 245). The role of the interviewer is to actively listen and not interrupt (Brinkmann, 2014, p. 286). One underlying assumption of this interview type is that the necessary questions to gather information on the research topic are unknown at the beginning, thus making a list of questions obsolete (Berg, 2001, p. 70). The aim of unstructured interviewing should be to gain insights into the individual perspectives of the interviewee (Qu & Dumay, 2011, p. 245). A potential disadvantage of this method is that the course of the interview is rather controlled by the interviewee than the interviewer and therefore issues deemed to be important by the researcher may be left out (Brinkmann, 2014, p. 286). As I had already an idea of what I wanted to know from the interviewees, the unstructured interview was not appropriate for data collection as well.

The semi-structured interview is the most common data collection method in qualitative research (Qu & Dumay, 2011, p. 246) and combines the predetermined questions and topics of the structured interview with the intuitive ad-hoc generation of questions of the unstructured interview (Berg, 2001, p. 70). Kvale and Brinkmann (2009, p. 3) define the semi-structured life world interview "... as an interview with the purpose of obtaining descriptions of the life world of the interviewee in order to interpret the meaning of the described phenomena". This definition highlights that interviews have the purpose of knowledge generation. An interview guideline, which is structured into themes, helps to conduct the interview in a systematic manner but also allows the interviewer to dig deeper and ask the respondent to elaborate in more detail on statements or topics of interest (Qu & Dumay, 2011, p. 246). Underlying assumptions of this approach are that questions should be formulated with the vocabulary of the interview subject and researchers should "approach the world from the subject's perspective" (Berg, 2001, p. 70). An important advantage is that hidden facets of individual or organizational behavior can be elucidated. Especially, when the aim of a study is to gain insights into individuals' perceptions of the social world, the semi-structured interview is an appropriate and effective method, as respondents have the possibility to answer in their own terms (Qu & Dumay, 2011, p. 246). As opposed to structured interviews, semi-structured interviews can make better use of dialogues to produce knowledge, as immediately following up on the interviewees' statements is allowed and encouraged, which provides the interviewer with the opportunity to participate in generating knowledge (Brinkmann, 2014, p. 286). An advantage over unstructured interviews is that the interviewer has more control over the thematic direction of the interview and can ensure that the focus remains on issues that are perceived to be important for the research project (Brinkmann, 2014, p. 286). However, semi-structured interviews need to be carefully planned and require the interviewer to be well trained in asking the right questions and correctly interpreting the answers of the respondents in the interview situation (Qu & Dumay, 2011, p. 247).

The flexibility of the semi-structured interview method as well as its suitability for examining attitudes, perceptions and

hidden facets of individual behavior convinced me to apply this interview type to examine the group processes in agile product development projects. Guided by the initial, rather general research question of the success factors of agile teamwork in product development projects in the manufacturing industry, I first familiarized myself with the basic pillars of agile product development, as practiced in the case company. As a next step, I reviewed the literature on new product development and cross-functional teams for relevant theories and empirical studies that aim at explaining team performance and new product success. The results of this review were sorted by topic and summarized in a Word document in order to formulate questions for the interview guideline, which were adapted to the context of agile product development.

The data were collected by conducting 14 semi-standardized interviews using an interview guideline with members of the two development teams of Project Colossus and Project Homestretch. The interview guidelines were adapted according to the roles of the interviewees. Therefore, there was a slight difference in the questions asked to members of the Product Owner Team (POT), the Agile Coach, and members of the Work Team. I started with interviewing two POT members and the Agile Coach of Project Colossus, next I spoke with three POT members and the Agile Coach of Project Homestretch. One and two weeks later, the Work Team members of the respective projects got their turn. I interviewed three members of Project Homestretch and four of Project Colossus. After the first round of interviews with each role, I further refined the interview guideline by adding questions about some significant events or topics mentioned by the first interviewees. Furthermore, after a first round of analysis I put increased emphasis on instances of decision-making and problem-solving as well as on disruptive factors in cross-functional coordination and collaboration. Nonetheless, every interview focused on the implementation of the agile methodology in the company and the course of the development project since then. The aspects covered in the interview guideline were the respondents expectations towards the new way of working, perceived changes in comparison to the prior project management method, challenges and successes in the project in general and with the agile methodology in particular, team cohesion and quality of collaboration, conflicts, (group) decision-making, responsibility, transparency, time and resource management, and autonomy. The interviews offered a good insight into the perceptions and attitudes of the interviewees towards agile product development and enabled me to grasp an understanding of what the pressing topics are in collaboration and coordination of cross-functional teams in new product development. As suggested by Berg (2001, p. 77), the language level of the respondents was taken into account in preparing the interviews and the interview guideline was tested and revised in advance. To ensure that the interviewees are able to easily comprehend my questions and to prevent misunderstandings and ambiguity, the interviews were carried out in German, the mother language of both interviewees and interviewer. All interviews took place within a time span of 15 days in October 2019 in a meeting room at a high table in the interviewees' company. On average the interviews took 45 minutes, the shortest lasting 20 minutes and the longest 60 minutes. I never conducted more than four interviews a day and made sure to make notes about particularly interesting or outstanding statements during the interviews. In addition, the interviews were recorded with a smartphone and fully transcribed usually on the same day. The interviewees were guaranteed anonymity in order to create a safe interview environment in which they can express themselves freely. For this reason, the transcripts have been anonymized.

For the purpose of data triangulation, other sources of relevant information, in the form of company documents (i.e. presentations on the introduction of agile product development, earlier interviews conducted by the company, and details of the projects) and notes of informal conversations at the company, were considered too. Furthermore, I used the notes I made during the interviews and memos on theoretical considerations and ideas I wrote during the initial phase of analysis to enrich my data.

3.4. Data analysis

Data analysis, i.e. coding the data, is considered the central process in grounded theory studies (Flick, 2009, p. 435). As already mentioned, data collection and analysis are carried out simultaneously within this type of research. The overarching objective of data analysis in the grounded theory methodology is theory development. Basically, coding in such studies has two sub-goals: (1) developing an understanding of the phenomenon under study, which requires an open-minded approach to analyzing the data, and (2) identifying an underlying structure, process or core category (Flick, 2009, p. 436). Strauss and Corbin (1998) differentiate between three procedures that may be used to work with texts in their approach to the grounded theory methodology: open, axial and selective coding. They understand coding as the central process behind theory building, in which data are ruptured, abstracted, and reassembled in novel ways (Flick, 2009, p. 307; Strauss & Corbin, 1998, p. 3). These procedures do not have a fixed sequence but usually start with open coding and get more abstract as data gathering and analysis proceed (Flick, 2009, p. 307). Open coding includes the identification and development of concepts and results in a list of codes and categories close to the data (Flick, 2009, p. 310; Strauss & Corbin, 1998, p. 74). With axial coding researchers aim at identifying relationships among the open codes and categories using the paradigm model, a general model that depicts the relations between a phenomenon, its causes and consequences, the context and the strategies of the people who are involved (Flick, 2009, p. 311; Strauss & Corbin, 1998, p. 114). Selective coding extends axial coding to a higher level of abstraction and involves the identification of a core concept or variable that relates to all categories, i.e. "the story of the case" (Flick, 2009, p. 312; Strauss & Corbin, 1998, p. 131).

Gioia et al. (2013, p. 20) distinguish between a first-order and a second-order analysis. Within the former, they check the data for relevant terms, codes, and categories. Thereby they try to stick closely to the informant terms, which leads to a huge number of categories already after the first ten or so interviews. This step can be compared to the process of open coding as described by Strauss and Corbin (1998). Accordingly, I began my analysis with sentence by sentence in-vivo coding of the first seven interview transcripts before conducting further interviews. In this first analysis I extracted interesting and relevant interview passages one-to-one and inserted them into an Excel sheet. In line with Gioia et al. (2013, p. 20), I went through these extracts, i.e. the in-vivo codes, again and tried to uncover similarities and differences among them. An analysis step similar to axial coding described by Strauss and Corbin (1998). To get an overview, I assigned a color to statements with a similar meaning and arranged them in my Excel sheet. Next, I tried to formulate first order concepts (Gioia et al., 2013, p. 20) to reduce the number of categories that emerged from the initial analysis. In their second-order analysis, Gioia et al. (2013, p. 20) move to the theoretical realm and seek to uncover themes and dimensions which they compound to reveal the larger story that explains what is going on in the data. In doing so, they put emphasis on concepts that seem to lack theoretical elaboration in the extant literature. So, as a next step I revisited the first-order concepts from a theoretical point of view and tried to derive a deeper structure that might offer an explanation for the way people work together in the agile teams under study. Simultaneously, I again consulted the literature on new product development and cross-functional teams to check whether there are extant theories that might explain the phenomena I observed during the interviews. Based on the interim results of my analysis, I familiarized myself more deeply with the coordination literature and found that there is a lack of research that integrates formal and informal or contextualized and emergent coordination mechanisms in cross-functional teams (Okhuysen & Bechky, 2009). As agile product development is tightly structured and thus naturally incorporates diverse formal coordination mechanisms, I wanted to find out more about informal mechanisms and the interplay of formal and informal mechanisms. As already mentioned, I thus decided to focus the subsequent interviews on instances of interaction, i.e. decision-making and problem-solving situations, on the one hand and to inquire about disruptive factors in interdisciplinary coordination on the other. After I transcribed the last seven interviews, I coded them line-by-line with the first-order concepts and second-order themes in mind. After coding the transcripts, I had support for the extant concepts and some new first-order concepts that added up to form new second-order themes. This was actually not surprising, because the last interviews added the perspective of the Work Team members to the data. Thus, I revisited the transcripts of the interviews with the POTs and the coaches again to make sure I did not overlook statements that turned out to be relevant. In fact, I found support for the new concepts and themes in these transcripts. Data collection in the Gioia Methodology usually ends, when the analysis has born a practicable collection of concepts and themes and theoretical saturation is reached (Gioia et al., 2013, p. 20; Glaser & Strauss, 1967). Because the number of my interview partners was limited from the start, the data collection ended with the last one. It would have been possible to speak to all interviewees again, but in my opinion that was not necessary. As a result of my analyses so far, I had a set of first-order concepts and second-order themes to further work with. In a next step, Gioia and colleagues try to further reduce the emergent second-order themes into "aggregate dimensions" (Gioia et al., 2013, p. 20). While trying to group my second-order themes and finding appropriate labels for the resulting aggregate dimensions, I once again consulted the literature and made an important discovery. I read some papers on cross-functional knowledge integration and realized that the success of agile teams may be determined by their ability to integrate diverse knowledge bases and that my data may provide important insights into how the process of knowledge integration unfolds in cross-functional teams. So, I went through my second-order themes again and partly reframed them to fit into the vocabulary used by scholars dealing with the phenomenon of knowledge integration. Afterwards, I distilled the second-order themes into five overarching theoretical dimensions. Having these, I was ready to build my data structure (see Figure 1 and Figure 2). The data structure visualizes how the researcher proceeded in the analysis, from raw data to concepts and themes. This graphical record of the analysis process is a vital element of validating thoroughness in qualitative research (Gioia et al., 2013, p. 20; Pratt, 2008; Tracy, 2010). In the following findings section, I will describe the aggregate dimensions and second order themes displayed in the data structure in more detail and provide example statements of the interviewees for each first order concept. The final process model that incorporates the relations between the dimensions will be presented and explicated in the last sub-section.

4. Knowledge integration in agile product development teams

The structure of the agile product development methodology with the 14-day sprints and the fixed meeting components would already provide a formal and timely framework to explain how knowledge is integrated in agile teams, however the analysis of the interviews revealed that the process of knowledge integration within this context is more nuanced, as team members permanently iterate between group-level and individual-level knowledge integration. At the group-level team members interact in formal and informal meetings to exchange coordination-related and problem-centered knowledge and concern themselves with a rather broad compilation of information and knowledge. Whereas, at the individual-level team members are primarily engaged with their individual task performance, processing the information they received from the interactions with their

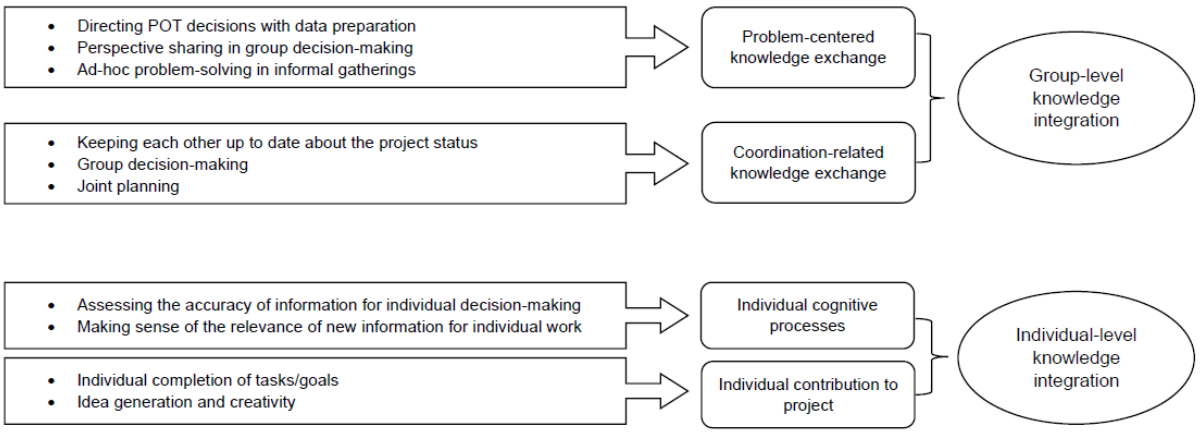

Figure 1: Data structure (part one)

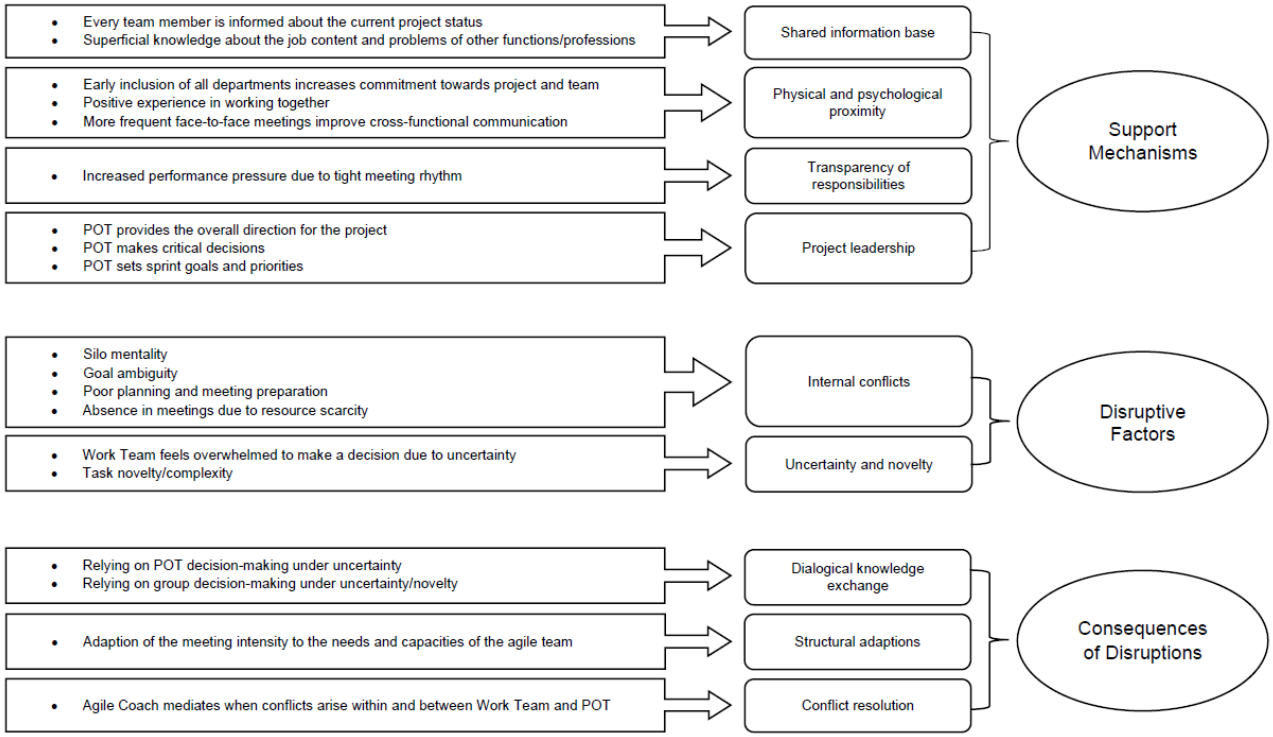

Figure 2: Data structure (part two)

colleagues and integrating them into their individual work. Thus, the data suggest that the process of knowledge integration is iterative in nature, meaning that the outcomes of the group-level provide the team members with input of different kinds for their individual work and that the team members in turn enrich the formal and informal interactions with their individual contributions. Figure 3 depicts this basic iterative model of knowledge integration in agile product development teams.

4.1. Group-level knowledge integration

The formal meetings at the transition from one sprint to the next serve as primary means for communication and information sharing across functions and roles throughout the project. They are the only occasion in which all members of the agile team come together: Agile Coach, Product Owner Team, and Work Team. Therein, team members have the possibility to share their ideas, present their results to their colleagues and give and receive feedback. Far more, the meetings are the main arena for large-scale problem-solving and group decision-making and allow for comprehensive discussions, thus representing the central platform for integrating different functional perspectives on bigger problems. Also, collective planning takes place within this formal context. Depending on the project phase and number of issues that may need to be discussed, these meetings may

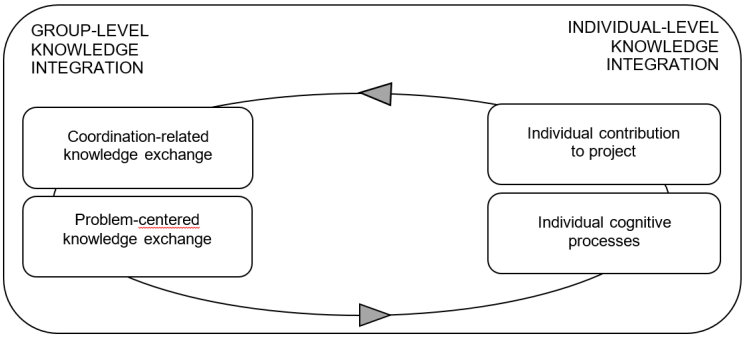

Figure 3: Basic iterations in the knowledge integration process

last up to four hours. However, also informal gatherings and the Daily-Stand-up-Meetings are used for knowledge sharing, whereby in these occasions, knowledge exchange is much more focused on problem-solving than in the biweekly sprint meetings. To sum up, within formal and informal interactions two different types of group-level knowledge integration take place: coordination-related knowledge exchange and problem-centered knowledge exchange. While the former mainly concerns cooperation, division of labor, planning and the overall direction of the project, the latter concentrates on exchange of expertise with the aim of cooperatively solving problems and creating innovations.

4.1.1. Coordination-related knowledge exchange

A fixed component of the biweekly sprint meetings is the presentation of results, in which team members share their achievements and encountered problems of the past two weeks. Therein the team members receive a broad range of information about the work content and obstacles of other departments and can develop a holistic picture of the overall project status. Also, the Daily-Stand-up-Meetings are used to share superficial information. Thus, keeping each other up-to-date about the project status represents a recurrent coordination and knowledge-integration practice in the agile teams under study. One of the engineers explained, that the regular meetings provide an effective platform for shortly discussing problems in a bigger round, because all the team members he would need for coordination are there, which makes the need to contact these people individually or to make an extra appointment obsolete, thus saving time.

> „Und so habe ich alle gleich einmal beieinander, die ich brauche, und dann kann ich das ganz schnell abwickeln zum Teil. [...] Ich sage mal, der ganze Besprechungsaufwand und Kommunikationsaufwand, den wir sonst gehabt haben, der ist jetzt minimiert worden."
>
> Mechanical Engineer, Project Colossus

However, at this point it is important to note that several interviewees highlighted the perceived inefficiency of information and knowledge sharing in the tight meeting structure. For example, the mechatronics engineer of project Homestretch claimed that most team members would only be affected by 20 percent of the content, and the other 80 percent are more of a "nice-to-know".

> „Richtig betreffen tut die meisten nur 20 Prozent. Aber die 20 Prozent sind halt wichtig. Da muss man die 80 Prozent Ineffizienz einfach als ‚aha, was die anderen Abteilungen leisten', annehmen."
>
> Mechatronics Engineer, Project Homestretch

With a general increase in group discussions, also the tendency to make decisions at the group-level rose. Thus, another common knowledge integration practice in agile teams is group decision-making, which primarily takes place in formal meetings. While decision-making is often related to problems or their solutions respectively, it has more of a coordination function, since decisions pave the further path of a project and provide the informative basis for the team members by which they arrange their individual efforts. The type of decisions that are made in the group are varied. It can be a decision between different problem-solving paths or design options, or smaller decisions where individual team members are unsure how to proceed and prefer to obtain the approval or support of the team. In the interviews, team members emphasized that they find their opinions to be a lot more substantial than they were before the introduction of agile product development. If all or many team members would agree then it would matter more than if only one person would stand in for an idea, they stated.

> „Es ist einfach auch ein Unterschied, ob jetzt ein ganzes Team eine Meinung hat und das vor dem POT präsentiert oder ob du allein mit deinem Chef das ausmachen musst. Und das hat einfach dann ein ganz anderes Gewicht, wenn das auf einmal ein ganzes Team trägt, die Entscheidung, oder die Idee [...]. Das macht auch einen wesentlichen Unterschied zu früher."
>
> Mechanical Engineer, Project Colossus

Obtaining different perspectives and making decisions together thus seems to increase commitment to the decisions

made and to reduce renegotiations of choices. As group decisions tend to create a feeling of security or support on the one hand, and group consensus on the other hand strengthens the perceived power of the group, decisions that could also be made by individual team members are pushed to the group-level. This stood out especially with Project Colossus. Possible reasons for this effect are elaborated in a later section on disruptive factors.

Another central coordination practice in agile product development is the detailed joint planning and the involvement of both POT and Work Team in doing so. A central responsibility of the POT is to integrate market demand and state of technology in their planning for the project and the Work Team. The consensus-oriented planning practice was new to the managers in the company and demanded them to invest considerably more time on planning, than they were used to. Because the POT should only specify what should be achieved and not how the team should perform the tasks, they had to learn to formulate the goals as clearly as possible and to provide the team members with autonomy and trust in the execution. While the POT formulates and proposes the goals for the upcoming sprint, the Work Team has the possibility to veto and stipulate adaptions. During Sprint Planning the team members commit themselves to the sprint goals set by the POT and the POT confirms that this is what they want. Thus, the outcome of such a planning meeting is a mutual agreement on the objectives for the next sprint. How important planning and goal setting is, was repeatedly emphasized in the interviews in both projects. One interviewee, for example, underlined that the quality of the product strongly depends on the quality of the goal specifications of the POT in the sprints.

> „[D]er Output vom Projekt hängt nicht nur vom Team ab, sondern sehr stark auch vom Product Owner Team. Also in der Qualität, in der sie die Aufgaben stellen, kommt auch die Qualität dann zum Schluss bei den Produkten raus."
>
> Simulation Engineer, Project Colossus

Once agreement on the sprint goals is achieved, the team autonomously splits the requirements of the POT into smaller activities and disperses them among the team members involved enabling the team members to work individually or in groups on their working packages. These activities are posted on the Team-Sprint-Board. As a result, the team members know at any time who is responsible for what and can also track the progress of work on the board. The predictable dependencies of the departments for the current sprint are already shown in the planning and activities. Thus, joint sprint planning fulfils important knowledge integration functions. First, the goals and activities formulated incorporate input from functional as well as management parties. Second, interdependencies of different areas of expertise are revealed. And third, the Sprint Boards visualize the outcomes of planning and serve as a point of reference and knowledge reservoir for both Work Team and POT.

4.1.2. Problem-centered knowledge exchange

As already implied, problem-centered knowledge exchange may take place in formal and informal interactions. A way of cross-functional knowledge integration that is practiced in the context of formal meetings is perspective sharing in group discussions. In group discussions the team members from different departments reveal their perspectives on problems or proposals for solutions and provide each other with feedback. This practice aims at enriching the individual understandings of the team members with other perspectives and valuing them for decision-making. In general, the interviewees agree that with the introduction of agile product development, problems and their solutions are discussed much more than before. Thus, topics are dealt with more intensively and the solutions are built on a broader knowledge base.

> „Und heute ist es so, man diskutiert das vielmehr im Team, wenn man ein Problem hat und [...] dann hat man auch gleich einmal viel mehr Meinungen. Das ist alles breiter aufgestellt dann, die Lösung oder die Vorschläge."
>
> Mechanical Engineer, Project Colossus

This tendency to discuss topics more in the group also means that the probability of overlooking important issues decreases and the potential of gaining new insights increases. Moreover, the interdisciplinary team setting enables some team members to contribute with completely different input, since they are involved in the project from the start.

> „Und der ist jetzt von Anfang an dabei und kann somit einen ganz anderen Input liefern, als er sonst könnte."
>
> Agile Coach, Project Homestretch

The formal meetings are of course not the only form of interaction and knowledge integration. Team members engage in ad-hoc problem-solving primarily within an informal context. While they are a fixed element in the agile product development methodology, the Daily-Stand-up-Meetings have a rather informal character. In these 15-minute meetings reporting of problems and quick coordination of expertise to resolve them are in the focus. Team members especially look for information that gets them ahead in their own work, but they also share their expertise on certain issues and support their colleagues in problem-solving, if desired.

> „[Ö]fter ist es so, dass man jemand anderen auch unterstützen kann, oder, dass du von jemand anderen unterstützt wirst."
>
> Testing Engineer, Project Colossus

Some team members also spontaneously seek out other opinions outside of the meetings while doing their tasks for the project. For example, the mechanical engineer of Project Homestretch explained, that he often consults the testing department when he designs a machine part, because they have the most experience with the machines.

> „Wenn ich zum Beispiel konstruiere, dann frage ich schon viel [bei Kollegen aus einer anderen Abteilung nach], weil die gerade die meiste Erfahrung haben mit den Maschinen."
>
> Mechanical Engineer, Project Homestretch

Sometimes, new dependencies or problems arise spontaneously, and team members inform their affected colleagues by making a phone call and engage in ad-hoc problem-solving.

> „Ein Beispiel ist, ein Konstrukteur ruft an: ‚Ich habe da jetzt etwas geändert, ich glaube das betrifft [ein spezifisches Bauteil]', [...] der hat das Gefühl, da tut sich was, dann fragt er, das ist ein Anruf, das kostet ihm 30 Sekunden und dann schau ich mir das an."
>
> Mechatronics Engineer, Project Homestretch

While group decision-making fulfills a coordinative function, POT decision-making is more problem centered. Not all decisions are meant to be made by the group or individual team members. The critical issues in the project, e.g. target specifications or make-or-buy decisions, are in the responsibility of the Product Owner Team. However, they need information from the Work Team as a basis for decision-making, as they cannot dispose of all the necessary details, due to their engagement in multiple projects and their departmental responsibilities. Thus, it is up to the Work Team to provide the POT with data for decision-making – a central knowledge integration practice, that guides the flow of information from team members to POT. The mechanical engineer of Project Colossus explained, that if any decisions are pending, they try to prepare the issue as best as possible for the sprint transition so that the POT can make a decision.

> „Also grundsätzlich ist es so, wir versuchen, [...] wenn irgendwelche Entscheidungen anstehen, die Thematik bestmöglich aufzubereiten für den Sprintübergang, damit das POT Team dann eine Entscheidung fällen kann. Die brauchen natürlich Infos, die können nicht alles wissen."
>
> Mechanical Engineer, Project Colossus

Thereby, the information asymmetry between POT and Work Team is an inherent point. Some of the interviewees stated, that the power of the Work Team is considerably higher because in total they know more about the product and the possible approaches to problem-solving. The difficulty for the POT then is to make speedy decisions based on the facts presented to them in the sprint meetings and to trust that the members of the Work Team have dealt with the topic sufficiently and rationally present the decision options. Occasionally, team members present three alternatives, but direct the decision to their favorite option by preparing this alternative more detailed than the others. Thus, team members carefully select the information they share with the POT in the sprint presentations.

4.2. Individual-level knowledge integration

As already mentioned, the process of knowledge integration appears to be iterative in nature. Thus, group-level and individual-level knowledge integration cannot be strictly separated from each other in terms of time, but rather happen simultaneously continuously providing each other with input from their respective integration outcomes. Especially during the sprint meetings high information-processing and sensemaking demands are posed to the team members. They are confronted with a lot of new information, problems, dependencies, as well as information about external market or technology changes brought in by the POT. The team members have to process these novelties accordingly and integrate their meaning in their own bounded worldview.

4.2.1. Individual cognitive processes

A central aspect of individual work that already starts in the meetings is information-processing. Thereby, making sense of the relevance of new information for one's own work represents an important knowledge integration practice at the individual level. The data have shown that the regular reporting of results and group discussions do not constitute an intensive engagement with each other's knowledge, rather team members principally take only the information and knowledge necessary for their own work with them from the sprint meetings. Especially in the beginning of the agile projects, information overload was an issue as the amount of information that team members had to process rose considerably compared to prior project work. As one team member stated, you get a lot of information, and at the beginning you do not know how to deal with it.

> „[M]an erfährt viel, bekommt sehr viel Information, und am Anfang weiß man auch nicht, wie man mit dem umgehen soll."
>
> Simulation Engineer, Project Colossus

Thus, the team members had to learn, how to process the significantly higher amount of information. A project's testing engineer explained how to deal with all the new information in one simple sentence. He stated that you would have to pull out what is relevant to you, implying that you should not really care about the rest.

> „[D]as was für dich relevant ist, musst du dir rausziehen."
>
> Testing Engineer, Project Colossus

The perceived value of information content also impacts the average attendance of the team members in the meetings. While attendance is mandatory, most of the team members decide on their own, if it is necessary for them to attend the meetings. For example, the controller of Project Colossus questions the usefulness of her presence in deep technical discussions because she sees no added value for her work.

> „Weil, wenn die die ganze Zeit wirklich nur über das Technische reden, was mache ich dann dort, wenn ich keinen Mehrwert habe?"

Controller, Project Colossus

Another individual cognitive process that plays an important role for knowledge integration, is the assessment of the accuracy of a piece of information for individual decision-making. Several interviewees, both Work Team and POT members, highlighted that a big challenge in making decisions is to have the right information at hand.

> „Ja eigentlich ist es die Herausforderung, dass man sicher die richtigen Informationen hat, wenn man eine Entscheidung treffen muss, auf welcher Basis, welchen Fakten, dass ich mir sicher bin, das ist so."
>
> Testing Engineer, Project Colossus

Some interviewees reported that they often rely on gut instinct when making decisions. It seems that the individual cognitive processing ability is often insufficient to include all information in the decision-making process, which is why team members rely on their intuition. Thereby they integrate their experience with the other information received.

4.2.2. Individual contribution to the project

Task completion, which represents the main part of individual work during a sprint, happens primarily outside of the meetings and other instances of interaction. The task assignments that are the outcome of Sprint Planning serve as important basis for the individual work phase. They represent an input that goes without further reflections on or discussions of meaning, because the task assignments are tailored to the skills of the team member who is responsible for completion and they were jointly developed in the sprint meeting. Thus, the specialists mainly work alone to fulfil the tasks agreed on for the current sprint. Each team member is responsible for how they come to performing their task.

> „[U]nd jetzt gibt es wirklich die verschiedenen Abteilungen [...], die nehmen ihre Aufgaben mit und es muss sich jeder im Team darum kümmern."
>
> Mechanical Engineer, Project Homestretch

In completing their task assignments, the team members integrate the obtained knowledge in the form of multiple perspectives, group or management decisions, solutions, and goals, from presentations, discussions, and planning in their individual contribution to the project.

Besides the fulfilment of tasks, integral parts of individual work are idea generation and creativity. In the beginning of projects, the team members usually have more freedom to elaborate on own ideas as the decision-making corridor is more open. However, as the project proceeds, choices get more and more constrained. Furthermore, the predefined goals of the POT determine the direction of individual work. As a member of the POT of Project Homestretch explained, some team members may just do what the tasks say, and in the past, they did what they thought, and maybe it was more.

> „Vielleicht ist es bei manchen Teammitgliedern auch so, sie machen das, was auf den Aufgaben draufsteht und früher haben sie das gemacht, was sie sich gedacht haben, und es war vielleicht sogar mehr."
>
> Member of the POT, Project Homestretch

Whereas a team member explained that he just has no time to be creative. Due to the high number of projects, he is engaged in, he can only manage to get done what he needs to, but not more.

> "Das geht sich aber auf der Projektdichte nicht aus. Da ist man froh, dass man das liefern kann, was man muss. Und die Pflicht, die geht sich gerade noch aus, für die Kür hätte ich gerne mehr Zeit."
>
> Mechatronics Engineer, Project Homestretch

However, the manner in which to achieve desired outcomes is rarely given. Only the expected result is provided, how the team members get there, is always up to them. So, from that point of view, they can live out their creativity in finding solutions to predefined problems in the later project phases.

4.3. Support mechanisms

The data analyzed suggests that knowledge integration in agile teams is supported by formal and informal coordination mechanisms. These support mechanisms tend to reduce the need for coordination-related knowledge exchange in agile teams by substituting for dialogical knowledge exchange. Figure 4 on the next page illustrates the mechanisms identified and their effect on group-level knowledge integration. In the following, I will explain in more detail how a shared information base, physical and psychological proximity, transparency of responsibilities, and project leadership may reduce the need for knowledge exchange in agile product development teams.

4.3.1. Shared information base

At the end of a sprint cycle, in the DEMO, the results of the work of the last 14 days are presented by the team members. This is usually aided by a PowerPoint document, which the members of the Work Team fill with pictures and descriptions to visualize their outcomes. In this phase of the meeting, comments or discussions are usually not desired. Rather, the mutual presentations should keep the team members on an equal level of information regarding project status and current topics. The results presented may include completed tasks, e.g. technical solutions, design solutions, or calculations, or also encountered problems that held the team members off from successfully delivering their contributions. During the sprint cycle achievements and pending problems are shared in the Daily-Stand-up-Meetings. It follows that every team member is informed about the current project status, providing that they attend the meetings. This shared

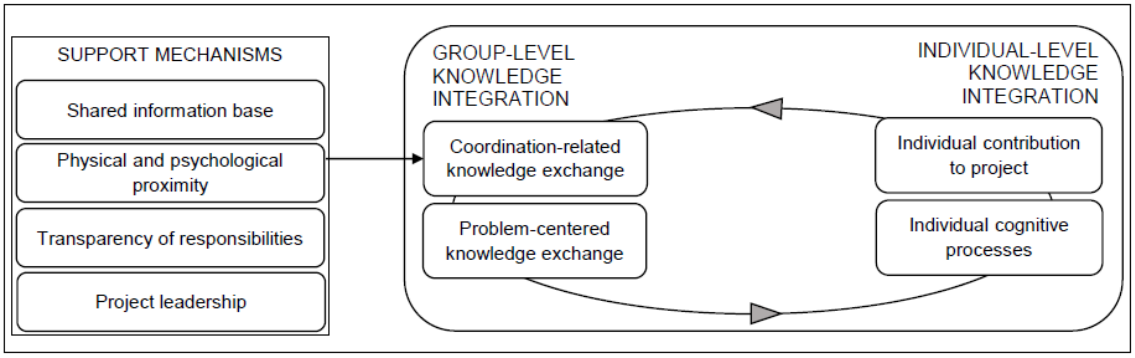

Figure 4: Support mechanisms in the knowledge integration process

level of information is particularly appreciated by many team members. While in the past they often had to get information themselves to get ahead, the flow of information has improved with the implementation of agile methods.

> „Naja, die Erwartung ist die, [...] dass man in einem ständigen Austausch mit der Gruppe ist [...], dass jeder Bescheid weiß, wie ist der Stand auch bezüglich Gesamtprojekt."
>
> Member of the POT, Project Colossus

The mutual presentations seem to reduce the need for subsequent bilateral exchange of knowledge by providing sufficient information to enable task completion in individual work. In the quote below, a team member highlights the advantages of a shared level of information about the project status in coordinating work. If certain tasks demand closer collaboration with colleagues from other departments, he does not have to explain again what the task is about or what his problems are, because the other team members were there at the sprint meetings and already know.

> "[D]ann muss ich dem das nicht lange erklären, um was es geht und einen Termin wieder ausmachen, sondern der war dabei direkt beim Sprint oder bei den Dailys, der weiß sofort um was es geht, der nimmt sich die Aufgabe mit."
>
> Mechanical Engineer, Project Colossus

Furthermore, the regular exchange of information in informal and formal interactions improves individuals' knowledge about the work and respective challenges of their team colleagues. This superficial knowledge about the job content of other functions appears to support coordination in agile teams. The interviewees emphasized that they are able to get to know and understand their colleagues, their work and the associated challenges much better through the regular gatherings and exchanges. In other words, mutual understanding is promoted. As one of the team members explained, in former times he often did not know what his colleagues were doing, and they did not know what he was doing. As a result, they talked at cross-purposes or their components did not fit together at all.

> „Die haben oft, also wir haben nicht gewusst was sie machen und sie haben nicht gewusst was wir machen und da hat man dann oft aneinander vorbeigeredet oder es hat dann einfach überhaupt nicht zusammengepasst."
>
> Mechanical Engineer, Project Colossus

However, the frequent communication across functions reduced problems of this kind and increased interaction further effectuated that team members not only know about each other's problems, but also about their skills, which makes it easier for them to locate experts to consult in the event of difficulties.

> „Und jetzt weiß ich was die Probleme vom Konstrukteur sind und der weiß was meine Probleme sind. Und ich weiß auch, was die Konstrukteure können."
>
> Simulation Engineer, Project Colossus

The regular meetings in agile project management resulted in the development of a shared information base about the overall project, wherein every team member is informed about the current project status and disposes of superficial knowledge about the job content and problems of other functions or professions. The information shared in meetings is rather broad than deep and supports the process of knowledge integration in reducing the need for subsequent bilateral exchanges on general topics, making collaboration more focused. Furthermore, the regular mutual communication of achievements and problems in the meetings facilitates the development of transactive memory, i.e. who knows what in the team, thereby reducing effort to identify experts for joint problem-solving.

4.3.2. Physical and psychological proximity

With the implementation of agile product development, the collaboration in the project teams inevitably became closer due to the regularity of the obligatory face-to-face meetings. While many project members stated that collaboration within the development teams has always been good, the implementation of the agile product development methodology brought about improvements in teamwork,

they agreed. Through the frequent face-to-face meetings, physical proximity of the team members was increased, and the employees of the different departments developed a stronger sense of belonging to the team and a feeling of togetherness. Thus, also psychological proximity to the team and the product grew. The majority of the interviewees sees the regular information and experience exchange between the departments and the short, rather informal coordination in the Daily-Stand-up-Meetings as a great benefit of the agile methodology. As one of the interviewees stated, the change in the intensity of working together is a big advantage, because you are just so much closer to each other and you are in constant exchange with colleagues from other departments.

> „Ich meine, die Zusammenarbeit ist natürlich schon ein großer Vorteil von der Veränderung her, weil man einfach viel mehr beieinander ist und sich ständig austauscht."
>
> Testing Engineer, Project Colossus

Some departments that are located in a separate building have previously been perceived as external service providers that only fulfill order after order without caring much about product or project success. Now, as one team member stated, they are much more involved in the project and can identify more with the product as a whole and are perceived as real team members.

> „Und jetzt sind die viel mehr integriert und haben einfach auch einen ganz anderen Bezug zu dem. Die werden ganz anders eingebunden. Und ja, ich glaube, dass man sich dann auch ganz anders identifiziert mit dem Projekt."
>
> Mechanical Engineer, Project Colossus

Moreover, the early involvement of these departments in the development team changed their sense of responsibility for the success of the project. As one technical services engineer stated, if you get involved, you can really make a difference.

> „Ja, weil man hat mehr Verantwortung für das Projekt, weil man einfach auch, wenn man sich einbringt, kann man echt was weiterbringen."
>
> Simulation Engineer, Project Colossus

Importantly, a member of a Product Owner Team observed that after you meet regularly, differing departmental worlds simply grow together through experience exchange and mutual support. He further suggested that this regularity is what drives the project forward.

> „Nachdem man sich aber regelmäßig trifft, wachsen die Welten einfach zusammen. Einfach dieses regelmäßige Treffen, Austauschen, ‚he was machst du gerade, was brauchst du gerade und was brauchen wir gerade'. Da bringt einfach diese Regelmäßigkeit das Projekt voran glaube ich."
>
> Member of the POT, Project Homestretch

Summing up, the frequent face-to-face meetings in agile product development increased physical proximity, thereby making collaboration in the teams closer and improving communication across functions. Moreover, the early inclusion of all departments increased team members' commitment towards the project and the team. However, positive experience in working together plays a crucial role in determining teamwork quality. Finally, the close collaboration in the agile teams and team member familiarity also led to the development of psychological proximity. This perceived proximity to other team members and the product to be developed serves as support mechanism for knowledge integration, as it increases team members' sense of responsibility and aids in aligning the different contributions of the team members by providing a common point of reference.

4.3.3. Transparency of responsibilities

Many team members reported that the transparency of the division of responsibilities, reinforced by the visualization on the Sprint Board, and the regular meetings make them feel more obliged to complete the tasks within the mandated 14-day time horizon or at least to think about an approach to solving a problem, because nobody wants to stand there empty-handed during the presentation at the end of the sprint.

> „Und so ist halt schon, das steht am Board und in zwei Wochen kommen wir wieder zusammen und dann muss halt was präsentiert werden und wenn der nichts hat, schaut es auch ein wenig blöd aus und das [...] will dann eigentlich auch jeder im Grunde vermeiden, dass er dann mit leeren Händen dasteht."
>
> Mechanical Engineer, Project Colossus

The Project Colossus controller stated that she feels more pressured to deliver results in the agile way of working or has a guilty conscience towards the team if she is not able to deliver.

> „Ich fühle mich viel mehr unter Druck gesetzt. Weil, man sieht sich viel öfter. Also unter Druck gesetzt, ich habe ein schlechteres Gewissen, weil ich weiß am Montag ist das wieder, ich muss das da wirklich bringen."
>
> Controller, Project Colossus

So, with the meeting intensity also the performance pressure rose for the team members. Due to the 14-day sprints the time span to complete tasks is rather short. On top of that, joint planning and distribution of tasks, including the display on the Team-Sprint-Board, increased the transparency of responsibilities, which made the team members feel more obliged to complete the tasks until the next sprint to avoid the embarrassment of not being able to deliver results for the team. The transparency of responsibilities supports knowledge integration in providing the team members with a clear

allocation of tasks, making subsequent discussions over duties largely obsolete. Furthermore, the Team-Sprint-Board incorporates the mutual expectations of the team concerning the performance in the upcoming two weeks and might be seen as the visualization of the team's aspiration level.

4.3.4. Project leadership

While the central idea of the agile methodology is to set up self-leading teams and provide them with more autonomy in carrying out the development project, the interview data have shown that the members of the Work Team largely attribute the role of the leaders to the Product Owner Team. Several interviewees stated, that one of the main and most important responsibilities of the Product Owner Team is to provide the overall direction for the project. In other words, they develop the vision for the product.

> „Das POT trifft die Entscheidungen und gibt einfach die Richtung vor und motiviert dann die Leute und wenn man wo schauen muss ist, dass das POT passt."
>
> Controller, Project Colossus

Another important task of the POT is to set sprint goals and priorities. This project management task is important, as it provides the Work Team members with a frame for their individual tasks. With the preestablished goals in mind, the team members then only have to decide how to meet the requirements of the POT. This intended split between what to do and how to do it, represents a central feature in agile product development. As a POT member of Project Homestretch mentioned, setting precise goals and being present in meetings are crucial factors that determine the quality of collaboration in agile teams.

> „[W]as man halt lernen muss ist das Thema konkrete Ziele auch setzen für die Sprintübergänge und dort einfach schauen, dass man laufend präsent ist."
>
> Member of the POT, Project Homestretch

When asked about the distribution of decision-making authority, most of the interviewees talked about some kind of rule of thumb that indicates, whether they can make the decision themselves, if it should be a group decision, or if the POT needs to concern itself with the topic. This rule of thumb developed over time. In the beginning the team members were sometimes uncertain about how far their autonomy in decision-making would go. In general, they agree that details or approaches to problem-solving are meant for single or group decisions and the POT is in charge of making the critical decisions in the projects, like target specifications or make-or-buy decisions.

> „Ja ich sage mal, wenn es um Details geht oder wie ich zu der Lösung komme, das ist eher das, wo wir als Team entscheiden, aber wenn es um Grundsatzentscheidungen geht, gerade auch was in einem Pflichtenheft steht, das muss halt einfach vom POT kommen."
>
> Mechanical Engineer, Project Colossus

As already mentioned, the members of the POT often have to rely on the information they get from the Work Team. So, trust in the integrity and thoroughness of the data is important when it comes to POT decision-making. A POT member mentioned that he especially has an eye on the way the results of a sprint are presented to him. Outgoing individuals, who can well present themselves, quickly sell their favored solution as the only truth on the planet. However, he added that in the end he bears responsibility for technical decisions and intensely relies on his gut feeling when making decisions of this kind.

> "Technisch gesehen liegt die Verantwortung ganz klar bei mir und ich verlass mich das extrem viel aufs Bauchgefühl und wie mir was präsentiert wird, wie sattelfest die Leute da sind, wie einig sie sich sind."
>
> Member of the POT, Project Colossus

The Product Owner Team clearly takes over the leadership role in the two agile teams under study. However, it is important to mention that there are mostly one or two persons in the POT, who drive the leadership role and motivate people. Nonetheless, the POT seeks to appear as one management (not leader) team on the outset. Project leadership, as described above, supports the knowledge integration process by reducing the need for coordination-related knowledge exchange. In providing an overall direction for the project and setting sprint goals and priorities, the POT fulfils central coordination mechanisms. Furthermore, the distribution of decision-making authority reduces the need for knowledge exchange between the agile roles.

4.4. Disruptive factors

Data analysis revealed that there are two types of disruptive factors affecting group-level knowledge integration in different ways. On the one hand, team internal conflicts of different causes temporarily diminish the effects of the support mechanisms and thereby increase the need for coordination-related knowledge exchange. On the other hand, environmental uncertainty and task novelty directly intensify problem-centered and coordination-related knowledge exchange in the agile teams. Figure 5 depicts these effects. The empirical background to the disruptive factors is described on the following pages.

4.4.1. Internal conflicts

The Agile Coach of Project Colossus stated that most of the conflicts or troubles in the team are triggered by poor planning and meeting preparation. The Agile Coach of Project Homestretch agrees in stating that as soon as the POT is weakly prepared and discusses important issues during Sprint Planning in front of the team, the mood in the Work Team deteriorates, immediately giving rise to conflicts.

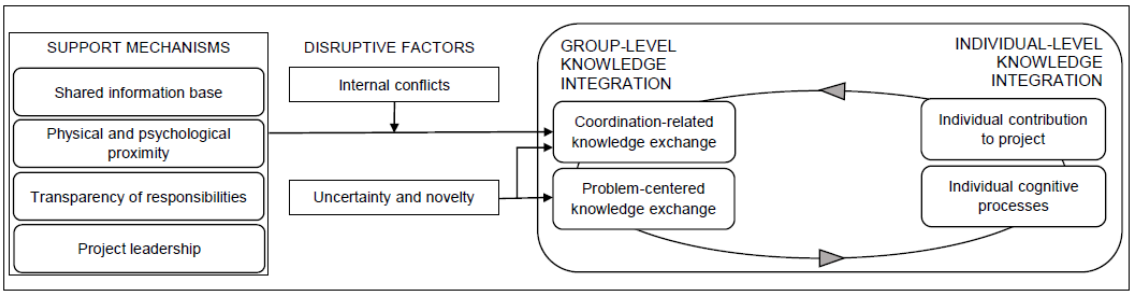

Figure 5: Disruptive factors in the knowledge integration process

> „Wir stellen einfach fest, ich sage jetzt mal, behaupte ich, in 85% der Fälle, wenn wir merken es sind Probleme im Team, Unruhen im Team, ja, also quasi auf gut Deutsch, irgendetwas passt nicht, wenn man es zurückverfolgt auf die Ursache des Problems, kommt man eigentlich darauf, dass man sagt ok, es liegt irgendwo in der Planung vom POT."
>
> Agile Coach, Project Colossus

Especially in the initial phase of agile product development, conflicts in the project teams arose, because the POT formulated the goals or tasks in too much detail on the Sprint Board. The mechanical engineer of project Homestretch mentioned, that this detailedness represented the biggest area of conflict in the beginning.

> „Die größeren Reibungspunkte waren vielleicht, dass die Aufgaben zu detailliert waren auf dem Sprintboard."
>
> Mechanical Engineer, Project Homestretch

As a result, the tasks or goals on the Sprint Board had to be negotiated and the supportive character of goal setting in project leadership got weakened, thereby increasing the need for coordination-related knowledge exchange in the teams. A related but independent topic is goal ambiguity. Especially in Project Colossus, goal ambiguity was a trigger for conflict between the Work Team and the POT. The cost of the machine was checked at a very late stage, with the result that the current design was far too expensive. The Agile Coach explained that there was a lack of understanding for this issue in team Colossus. The members of the Work Team were confused, because in their point of view, they have done exactly what the POT demanded them to do and have built the best machine possible.

> „Für ein Team ist das, die sehen das aus einer eigenen Brille und aus einer eigenen Sicht und im Team ist das teilweise auch, glaub ich, auf Unverständnis gestoßen, dass man gesagt hat ‚he was wollt ihr, wir haben genau das gemacht, eigentlich was ihr von uns wolltet, wir haben (aus deren Sicht) die beste Maschine gebaut, wieso jetzt auf einmal dieses Thema¿"
>
> Agile Coach, Project Colossus

The requirement of the project management was to build a highly innovative and novel machine that would outclass all previous models and the competition. Without paying much attention to the costs, the team developed the machine true to the goal that was set, to find out later that the machine is great, but far too expensive. As a result, there was a decrease in motivation, because the team members had to revise some of the key functions and design elements, of which they were proud. It took time for the team members to make sense of the cost issue. As a trigger of internal conflicts, goal ambiguity has detrimental effects on the knowledge integration process. While project leadership and accompanied goal setting are intended to support knowledge integration in agile product development teams by providing the team members with a point of reference by which they can carry out their project work, goal ambiguity diminishes this effect leading to undesired outcomes and project delay.

Due to resource scarcity many team members decide to absent themselves from the biweekly or Daily-Stand-up-Meetings, if they see no value for their own work or do not have any topics for the current sprint. Furthermore, the number of tasks for the overarching departments fluctuates considerably over the course of the project. Sometimes there are no topics for commercial departments or technical services in a sprint transition. As a result, the purchaser of Project Homestretch and others omit sprints, if they believe their attendance is not important and that their function or department has no issues.

> „Wenn ich sehe, dass es nicht so wichtig ist, oder glaube, dass der Einkauf keine Themen hat, dann bin ich in diesem Sprint nicht dabei."
>
> Purchaser, Project Homestretch

However, the team members should be present in the meetings in order to keep their general information about the project up-to-date or to be available for their colleagues if a topic that affects them arises spontaneously. Due to the strict implementation phase of the agile methodology, continuous presence is considered an important group norm. As described above, the Daily-Stand-up-Meetings and the other more formal meetings in the agile structure provide an arena

in which all the team members including the POT are available and topics with many interdependencies between departments and roles may be discussed straightforward. Thus, it is the (continuous) absence of project team members that leads to conflicts in the team.

> „Und das Nervige ist einfach, wenn die Leute, die man wirklich braucht, nicht da sind. Das ist das Nervige. Das ist dann, wo du dann auch den Unmut von den anderen spürst."
>
> Controller, Project Colossus

As the controller in Project Colossus put it, the absence is particularly negative and leads to resentment in the team if the person had been needed in the meeting and did not tell anybody that he or she would not appear. One of the interviewees expressed his frustration by implying that next time he would fail to appear, too.

> „Manchmal denke ich mir ok, jetzt ist der schon wieder nicht da, dann gehe ich das nächste Mal auch nicht, dann habe ich halt auch nicht Zeit, weil irgendein anderer Termin ist, oder was."
>
> Mechanical Engineer, Project Homestretch

The continuous absence of team members in the meetings impedes the development and maintenance of a shared information base, thus detracting the impact of the support mechanisms on group-level knowledge integration and increasing the need for dialogical knowledge exchange, because the absent team members need to be kept up-to-date outside the meeting context, if interdependencies arise. The aforementioned violation of group norms may further lead to conflicts that require the intervention of the Agile Coach and might necessitate the negotiation of interests among team members.

Finally, as already mentioned in the case description, silo mentality has been a major problem and conflict trigger at A-Machining for many years. While the introduction of agile product development and project management methods brought about some improvements, there are still occasions, in which department-centered thinking leads to conflicts in the project teams. As a POT member in project Homestretch explained, certain departments want to achieve their goals more vehemently than others without looking at the big picture.

> „Weil gewisse Abteilungen einfach ihre Ziele etwas vehementer erreichen wollen, ohne aufs große Ganze zu schauen."
>
> Member of the POT, Project Homestretch

This silo mentality is problematic, as it interrupts the knowledge integration process by increasing the potential for conflicts and subsequently the need for conflict resolution and coordination-related knowledge exchange. Moreover, conflicts possibly deviate team members' attention from the functional issues and problems in the project and might impair communication among the team members.

4.4.2. Uncertainty and novelty

While in agile product development the team members generally have more autonomy in decision-making, there are some decisions that the POT has to make because the team wants to protect themselves due to uncertainty or sees their competencies exceeded. Especially, the Work Team of Project Colossus is confronted with a high level of uncertainty and great pressure for success, putting extraordinary importance on decisions. The mechanical engineer of Project Colossus explained that the team would feel overwhelmed with certain decisions and could only prepare data for decision-making in the best possible way, but the decision would have to come from the POT. In such cases, the team would feel unable to make decisions.

> "Ja also man muss vielleicht schon sagen, dass sich hier und da vielleicht das Team bei gewissen Entscheidungen manchmal schon überfordert fühlt oder sagt einfach: ‚Das können wir nicht machen, wir können das nur bestmöglich aufbereiten, aber die Entscheidung muss dann vom POT kommen.' Also das kommt schon hier und da mal vor, dass wir uns dann nicht mehr in der Macht fühlen [...], dass wir gewisse Entscheidungen treffen."
>
> Mechanical Engineer, Project Colossus

Another externally triggered factor that might affect the knowledge integration process is task novelty. On the one hand, the new product development method triggered uncertainty. Agile methods were new to all team members and they did not really know what to expect. On the other hand, the Colossus project in particular was of an unusually large dimension for the company and many new ideas and concepts were created for it. The team's mechanical engineer described that because a lot was new, it was not clear at the beginning what challenges they would have and what else would come.

> „Und ja es war einfach dadurch, dass viel neu war, war es halt am Anfang noch nicht so klar, was wir für Herausforderungen haben und was dann noch alles dazu kommt."
>
> Mechanical Engineer, Project Colossus

When confronted with uncertainty and novelty, collaboration in the team tends to get closer and interactions more frequent. For example, the Daily-Stand-up-Meetings are more intensively used to quickly discuss pending problems and coordinate interdependencies and informal coordination and collaboration outside the fixed meeting components accelerates to uphold high team performance. Uncertainty and novelty disrupt the routine knowledge integration process because they require additional coordination efforts and cause team members to engage in verbal knowledge exchange more intensively. Furthermore, joint problem-solving is forced and the support mechanisms are largely insufficient to compensate for uncertainty and novelty.

4.5. Consequences of disruptions

Depending on the type of disruption, the strategies for coping with disruptive factors in the knowledge integration process vary. In general, the data revealed that in uncertain and novel contexts, there is a significant increase in dialogical knowledge exchange for both coordination and problem-solving. Moreover, the Agile Coaches might undertake structural adaptions, i.e. adapting the intensity of the meeting structure, to cope with uncertainty and prevent conflicts. Finally, to resolve internal conflicts, the Agile Coaches of the teams intervene with moderation techniques in discussions or individual talks to keep conflicts and their respective aftermaths in check.

4.5.1. Dialogical knowledge exchange

The phases of interaction, wherein team members meet face-to-face, become more important and more intensive as environmental uncertainty and the degree of task novelty rise. Team members increasingly rely on dialogic coordination to cope with the uncertainties that support mechanisms cannot resolve. Especially, group problem-solving and decision-making, formally as well as informally, are intensely used knowledge integration practices under these circumstances. In this regard, an engineer stated that if you are not sure what is right, then the whole thing becomes a team decision and you don't have to make it all by yourself.

> „Wenn man sich nicht sicher ist, was das Richtige ist, dann wird das Ganze eine Teamentscheidung und man muss das Ganze nicht allein fällen."
>
> Mechatronics Engineer, Project Homestretch

Overall, the level of uncertainty plays a major role in the individual perceptions about the meeting intensity and the necessity of escalating decision to the group-level. If uncertainty is high, for example because the project is at an early stage or unanticipated problems arise, the team members find the high frequency of the meetings more appropriate as if uncertainty is rather low, for example, because the project is close to the end and project work resembles more of a routine work without the need for extensive problem-solving. In uncertain or novel contexts, team members especially value the information content of the meetings and the possibility to discuss issues in a bigger round without having to call for additional meetings. However, as uncertainty turns rather low, for example in later project phases, in projects with a comparable low degree of novelty, or if team members do not have any tasks in the present sprint, the perceived appropriateness of meetings is low, as team members perceive the value of the information content of the meetings largely as "nice-to-know" but not necessary for their individual work. As already shown, attendance in the meetings is an important factor to enable knowledge sharing and integration in the project, because absence in the meetings negatively impacts collaboration by triggering detrimental conflicts in the team. Furthermore, the coordination practices that take place within the formal meetings may only be effective if all of the project team members attend the meeting.

In addition, the data revealed that team members increasingly rely on POT decision-making under uncertainty. Thus, under uncertain or novel circumstances, decision-making competencies are increasingly shifted to the POT and discussions within the biweekly meetings are more intense, seeking to cover all contingencies and to create a feeling of safety. A POT member in project Homestretch explained that at the beginning, where uncertainty about role competences and responsibilities was high, the Work Team tried to shift the decisions to the POT, which was a bit of a challenge, as agile product development foresees increased decision-making autonomy for the Work Team.

> "Das war am Anfang [...], ich will nicht sagen ein Hindernis, aber da hat das Team dann versucht eher den Weg zum Product Owner Team zu suchen. Bis sich das eingelebt hat, [...] dass sie viele Entscheidungen fällen dürfen, das hat etwas gedauert und war am Anfang [...] eine Herausforderung."
>
> Member of the POT, Project Homestretch

While project leadership has a fundamentally supportive effect in dealing with uncertainty, postponing the locus of decision-making from the Work Team to the POT also involves an increased effort for knowledge exchange, as the POT must first be brought up-to-date in order to enable a qualified decision.

4.5.2. Structural adaptions

In general, the degree of intensity to which the agile ceremonies are practiced, varies across the projects in the company and also within the course of single projects. The Agile Coach of project Homestretch stresses the importance of freedom of design, because not every phase of a project requires intensive communication on a daily basis and not every project demands the same intensity in collaboration. In the end, the POT and the Work Team should agree on a suitable adaption, that enables the exploitation of the advantages of the agile system, while at the same time fostering the acceptance of its formal elements.

> „Und das ist ganz wichtig bei jeder Methode. Man sollte sich Freiräume lassen, dass man sagt man macht es so oder so, wie es das Team oder das POT oder wie sie es gemeinsam sehen. Nur dann hat es einen Sinn, weil alles mit einem starren System ist dann wieder komplett falsch. [...] Vor allem für die Leute, die können sich nicht damit anfreunden."
>
> Agile Coach, Project Homestretch

Structural adaptations are an important mechanism to prevent conflicts that arise, for example, from being absent from meetings. With a lower number of meetings, the need for information of the team members tends to increase and

they perceive their presence in meetings to be more meaningful. Furthermore, by adjusting the intensity of the meetings and other ceremonies, the Agile Coaches can create an efficient framework for the required increase in dialogical knowledge exchange under uncertainty.

4.5.3. Increased effort for conflict resolution

For most of the Agile Coaches their role in agile projects represents only a small part of their total engagement in the company. They often have their main obligations in functional departments or in other agile projects as members of the Work Team. Therefore, a main challenge for them was to learn to keep a professional distance and avoid interfering in technical discussions with their own expertise. Nonetheless, the Agile Coach is deeply involved in the project as he or she is the first contact person for both Work Team and POT in case of collaboration problems or issues with the frame conditions and moderates all the agile ceremonies, even the Daily-Stand-up-Meetings if necessary. In applying moderation tricks, the Agile Coach can drive discussions, direct conversations, obtain contributions and resolve emerging conflicts at an early stage. The Agile Coach of Project Homestretch sees the value of his role especially in being a loyal or neutral person that mediates between the Work Team and the POT. Similarly, as quoted below, the Agile Coach of Project Colossus highlights the effectiveness of his interventions enabled by the professional distance to the development project and the general perception of his role as outsider.

> „Du bist eben der externe Faktor, der das steuern kann. Das lassen auch die Leute relativ schön zu."
>
> Agile Coach, Project Colossus

A central responsibility of the Agile Coach is to maintain a trouble-free workflow by removing barriers that distract the members of the project team from doing their work. The sources of such disturbances are manifold. As the Agile Coach of Project Colossus described, sometimes it is a matter of communication or collaboration between or within functions, or there are latent conflicts between Work Team and POT that need to be resolved. In the statement below, a member of the POT of Project Colossus highlights the general importance of the Agile Coach in the agile game and particularly points to the crucial ability of sensing conflicts or problems before they come to the surface.

> „[D]er agile Coach, der ist sozusagen eigentlich das Zünglein an der Waage. Für mich auch eine der absolut wichtigsten Personen in dem Spiel. Es hängt extrem von dem ab, was der spürt, ob er merkt, he da hat es was."
>
> Member of the POT, Project Colossus

As soon as the Agile Coach recognizes an emerging conflict, the first step is to directly confront the parties involved outside the meetings and to seek a clarifying conversation. If the coach senses a general tension in the team that cannot be attributed to individual team members, he has the opportunity to adapt the intensity of the agile ceremonies to improve the mood in the team again.

> „[M]an merkt, ok, es ist einfach permanent irgendwo eine gewisse Spannung, die man vielleicht gar nicht so offensichtlich sieht, aber man spürt sie, dann such ich einfach Gespräche, mit denjenigen, mit den Personen [...]"
>
> Agile Coach, Project Colossus

To summarize, at first glance, the role of the Agile Coach seemed to resemble those of simple moderators and mediators as frequently installed in group decision-making or conflict situations. However, on closer examination the role reveals to be more complex than expected, fulfilling important boundary spanning functions, such as maintaining the flow of communication and mediating between functions, and determining the design of the formal structure in the agile project. Through timely and appropriate interventions of the Agile Coach the need for intensive dialogue to overcome conflicts, clarify meanings and create shared understandings of tasks and responsibilities may be reduced.

4.6. An iterative process model of knowledge integration in agile product development teams

Based on the data presented in the previous sections, I will now put the different aggregate dimensions into relation and develop the iterative process model of knowledge integration in agile product development teams to summarize my findings. The analysis of the interviews showed that the process of knowledge integration iterates between phases of interaction, i.e. group-level knowledge integration, in which team members meet formally as well as informally, and phases of individual work, i.e. individual-level knowledge integration, wherein team members are engaged with their individual task performance. The data imply that the outcomes of the phases of interaction provide the team members with input of different kinds for their individual work and that the team members in turn enrich the formal and informal interactions with their individual contributions. This basic iterative process is visualized on the right side of Figure 6 on the next page, demonstrating the iterations between group-level and individual-level knowledge integration and the associated exchange of inputs and contributions.

Using the formal sprint structure as a frame, I start explaining the iterative process of knowledge integration with the formal interaction of the project team members in the biweekly sprint meetings, including upstream contribution and downstream input. As already outlined, the meeting opens with the presentation of the results of the previous sprint. Thereby, individual team members

contribute with presenting their completed tasks, alternative ideas for solving pending problems, newly encountered problems, or other issues, which demand further discussion and a group or POT decision. Thus, team members first of all

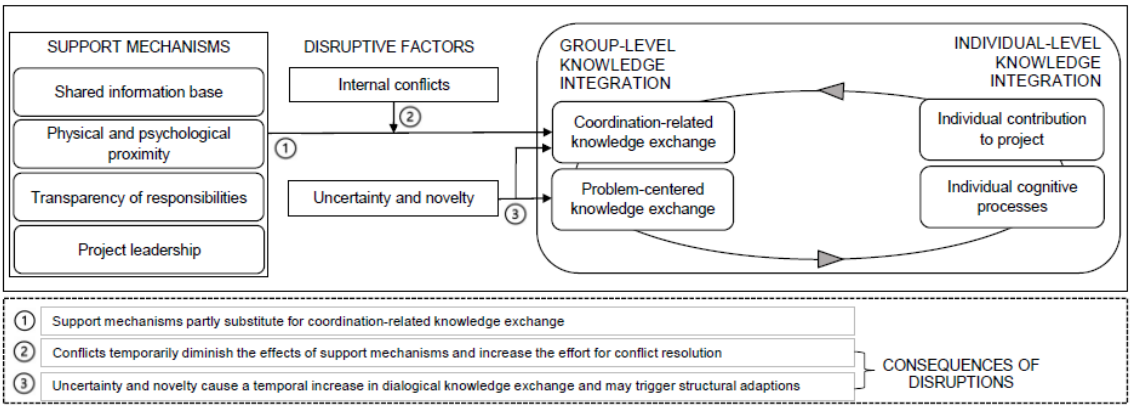

Figure 6: An iterative process model of knowledge integration in agile product development

get updated about the project status, including technical solutions, current problems of other team members, and pending decisions. After the initial presentation, there is time for group problem-solving and decision-making. Usually, this affects bigger problems or large-scale decisions, which require detailed examination through group discussion to be able to include as many different perspectives as possible in finding a solution or deciding which way to go. Individuals contribute to the discussion with their idiosyncratic viewpoint on the issue and their experience in working with the machine. As a result, team members may be provided with possible solutions or ideas for resolution, decisions, and also open questions, that may or may not affect their individual work. The outcomes of the previous meeting parts are then considered for The Conclave, the planning session of the POT, which happens detached from the Work Team. The individual POT members bring their demands and expectations into the discussion about the goal specifications for the next sprint, according to their roles as representatives of market, technology, production and project management. The outcome of this step are the goals for the next two weeks that are accepted by all POT members. Next, in Sprint Planning, the POT presents their agreed-on expectations for the upcoming sprint to the Work Team, whose members may question goals and priorities, or demand changes based on their experience and current workload. Once the goals are accepted by the two parties, the members of the Work Team engage in self-organized planning without the POT. The outcome of this planning stage are specific tasks that need to be completed individually or in groups until the next sprint transition in 14 days.

If a team member encounters problems or unexpected interdependencies within a sprint cycle, then additional, informal interaction might be necessary. The Daily-Stand-up-Meetings are in principle another planned part of the agile sprint cycle, but they are rather informal in nature. In these short meetings, team members primarily share their problems with others, point to interdependencies and contribute their experience and own perspectives to others' problems. In turn, the team members receive information on the sprint status, possible solutions to and multiple perspectives on smaller problems, and on whom to consult for given problems or direct offers of help. However, due to their history in working together, the team members have good knowledge about interdependencies and whom to consult for jointly solving smaller problems. Therefore, they directly contact the person they need to get ahead. Sometimes, it is just a phone call to point to a discovered interdependency between disciplines and sometimes, it is a coffee talk to exchange ideas and thoughts. However, informal interactions are always centered on a given problem and not on the project in general. Thus, knowledge exchange in these circumstances is highly focused and entails only the knowledge fragments necessary to solve a problem or coordinate an interdependency.

While individual work basically starts with the end of formal interaction, individual-level knowledge integration happens simultaneously with group-level knowledge integration. This is especially due to the individual information-processing and sensemaking demands posed to the team members during the sprint meeting. The team members are confronted with a lot of new information, problems, dependencies, as well as information about external market or technology changes brought in by the POT. The team members have to process these novelties accordingly and integrate their meaning in their own bounded worldview. These cognitive processes do not start after but during the meeting. Nonetheless, task completion, which represents the main part of individual work during a sprint including individual problem-solving and idea generation, happens primarily outside of interaction phases. The task assignments that are the outcome of Sprint Planning serve as important basis for the individual work phase. They represent an input that goes without further reflections on or discussions of meaning, because the task assignments are tailored to the skills of the team member who is responsible for completion and they were jointly developed in the meeting. As already shown in the description of the knowledge integration practices observed, team members principally take only the information and knowledge necessary for their own work with them from the sprint meetings. Therefore, they

integrate the obtained knowledge in the form of multiple perspectives, group or management decisions, solutions and goals, from presentations, discussions, and planning in fulfilling their task assignments. Also, insights gained from informal interaction are integrated by individuals. The informal interactions, dailies as well as ad-hoc coordination and collaboration, during a sprint and the associated feedback again include contributions and input in the form of smaller problems, own perspectives and discovered interdependencies, enriched with knowledge and experience from past informal interactions. The contributions of the individual team members, in particular their completed tasks, contain all inputs that were considered relevant by the responsible team member from formal and informal interactions over the last 14 days and are combined in the presentation of the results. However, the results presented are not necessarily solutions. Team members may also present bigger problems they encountered, prepared selection options for a decision too big to be made by a single team member, or also new ideas they have been working on to improve existing solutions. These individual contributions then are the basis for the other knowledge integration practices that take place within the biweekly formal meetings, e.g. group problem-solving and decision-making and planning.

While the basic iterative process model of knowledge integration in Figure 3 already shows well how phases of interaction and individual work iterate in the course of a sprint cycle and how inputs are transformed into contributions, there is still little information about the factors that influence knowledge integration practices. Thus, the support mechanisms that underly the knowledge integration process and the sensibility of knowledge integration practices to changes and its consequences shall now be integrated into the model. Support mechanisms like a shared information base, physical and psychological proximity, transparency of responsibilities, and project leadership reduce the need for dialogical knowledge exchange as they fulfil a coordination function. However, the reduction impact of the support mechanisms only applies to coordination-related knowledge exchange, which is implied by the long arrow in Figure 6. Data analysis further revealed that there are team internal as well as external factors that may trigger changes in coordination and collaboration demands that subsequently lead to an adaption of knowledge integration practices. External triggers for a change in coordination or collaboration demands can be subsumed under environmental uncertainty and task novelty. These factors raise the need for more intense interactions, formal as well as informal, and knowledge exchange. When confronted with novelty, collaboration in the team is closer and more frequent. If uncertainty is high, decision-making competencies are increasingly shifted to the POT and discussions within the biweekly meetings are more intense, seeking to cover all contingencies and to create a feeling of safety. In addition, consensus is desired to legitimize decisions and enable continuation of work with a better gut feeling. The Daily-Stand-up-Meetings are intensively used to quickly discuss pending problems and coordinate interdependencies and informal coordination and collaboration outside the fixed meeting components accelerates to uphold high team performance. In sum, the interaction phases, wherein team members meet face-to-face, become more important and more intensive as environmental uncertainty and the degree of task novelty rise. Team members increasingly rely on dialogic coordination to cope with the uncertainties that support mechanisms like shared information base or proximity cannot resolve. Especially, group problem-solving and decision-making, formally as well as informally, are intensely used knowledge integration practices under these circumstances. The Agile Coaches can accommodate the need for more dialogical knowledge exchange with undertaking structural adaptions, i.e. adapting the meeting intensity. Another important factor to cope with uncertainty is the leadership function of the Product Owner Team. In providing the Work Team with an overall direction and overtaking their responsibility to adequately integrate different viewpoints to solve problems and make decisions, they reduce the information-processing demands on the individual team members. As already implied, certain factors that arise as a result of individual work might trigger an increase in informal coordination and collaboration practices. For example, unexpectedly emerging interdependencies or newly encountered problems may necessitate the closer collaboration of different specialists. Essentially, these factors do not ascend due to changes in the team's external environment but represent the normal "surprises" when assumptions are tested and do not comply with initial expectations or requirements. Still, the typical trial-and-error processes in new product development that often come along with intensified collaboration and mutual adaptions increasingly occur in light of environmental uncertainty and task novelty. Thus, as shown in Figure 6, uncertainty and novelty lead to a temporal increase in dialogical knowledge exchange for both coordination and problem-solving. However, as soon as uncertainty and novelty reach a moderate level and things get back to "normal", the intensity of coordination and collaboration decreases and the phases of individual work in the knowledge integration process come to the fore again.

A team internal factor that changes coordination practices are conflicts, for example triggered by team member's absence in the formal meetings. While the physical presence of all team members in these meetings reduces the need for bilateral knowledge exchanges as problems occur or interdependencies are encountered, the absence of team members representing a concerned function does the opposite. This undesirable additional effort for coordination can, if absences accumulate, cause conflicts between team members and subsequently impair teamwork so that conflict resolution measures have to be taken by the Agile Coach. Usually, this goes hand in hand with a more intensive engagement with different viewpoints and negotiations of interests. Another major trigger for intensified discussions that could be avoided is unpreparedness of the POT. As the members of the Product Owner Teams are involved in multiple projects and concerned with management issues in their home departments,

their time for meeting preparation is limited. However, poor POT planning, which is often the result of ill-prepared members, raises additional coordination demands during the biweekly meetings. The formulation of ambiguous goals, the specification of detailed tasks instead of a rough direction, or the lack of certain points that are considered important in the current project phase by the team members lead to an increased need for discussion in Sprint Planning. As depicted in the model on Figure 6, internal conflicts seem to cancel the effect of the support mechanisms, which are supposed to reduce the exchange of coordination-related knowledge between different functions.

5. Discussion & Conclusion

5.1. Contributions

To address the scarcity of research on agile teams outside the software development context, the present study primarily aimed at exploring the success factors of agile teamwork. The organizational learning literature dealing with the change or increase in organizational knowledge provided the theoretical starting point for this examination. Two partly contradicting approaches to knowledge integration, the cross-learning perspective and the specialization perspective, were discussed. While the cross-learning view stresses that knowledge needs to be transferred between individuals and that knowledge boundaries need to be traversed with mechanisms and practices to enable knowledge integration (Majchrzak et al., 2012), proponents of the specialization approach argue that intensive knowledge exchange contradicts the very notion of specialization and poses excessive demands on individuals' cognitive capacities, thereby ignoring individuals' bounded rationality (Kieser & Koch, 2008). Empirical findings imply that extensive knowledge sharing is not key to successful knowledge integration, thereby contradicting the central conjecture of the cross-learning approach. Rather, extant empirical work suggests that certain practices and structural mechanisms reduce the need for knowledge sharing. However, recent studies on product development projects indicate that the need for and the engaging in knowledge sharing are dependent on the level of task novelty or innovativeness of the product or project (e.g. Schmickl & Kieser, 2008). While most of the studies on cross-functional teams in new product (e.g. Schmickl & Kieser, 2008) or new process development (e.g. Majchrzak et al., 2012) consider the overall level of uncertainty and its impact on knowledge integration, they do not show how knowledge integration mechanisms and practices change over time within the course of a project. Similarly, studies adopting a process perspective on knowledge integration in new product development do not account for changes in uncertainty or novelty over shorter periods of time (e.g. Enberg et al., 2006). To close this research gap, I examined the process of knowledge integration in two agile product development teams with special emphasis on changes in knowledge integration practices and mechanisms within the course of projects. Consequently, I developed an iterative process model of knowledge integration that shows (a) how agile teams integrate the diverse contributions of the individual team members into a new product, (b) how internal and external factors trigger alterations in knowledge integration practices, and (c) how agile teams adapt to the resulting changes in coordination and collaboration demands.

The present study contributes to the organizational learning literature on knowledge integration in three ways. First, the thesis adds important insights on the contingencies that determine the depth and content of knowledge exchange in project teams. Carlile and Rebentisch (2003, p. 1182) proposed that the complexity of knowledge integration in product development increases with the amount of dependencies between different specialized domains or departments in an organization. Accordingly, prior research suggests that the coordination of teams high in expertise diversity demands mechanisms beyond formal planning (Faraj & Sproull, 2000, p. 1555). Previous practice and process-based studies of knowledge integration, stress that excessive deep-level knowledge sharing is hardly found in multidisciplinary teams. These studies suggest that dialogical practices (Majchrzak et al., 2012) and structural support mechanisms like, modularization, prototyping and transactive memory (Kieser & Koch, 2008; Schmickl & Kieser, 2008), process specifications and presentation genres (Enberg, 2012), and a common digital space (Kellogg et al., 2006), facilitate knowledge integration by reducing the need for extensive knowledge exchange between specialists. Similarly, knowledge integration in the two agile development projects explored was aided by support mechanisms such as physical and psychological proximity, transparency of responsibilities, project leadership and a shared information base. These mechanisms, individually and in combination, reduced the need for extensive knowledge sharing among team members under "normal" circumstances, in which interdependencies were clear. Then, knowledge sharing in informal interactions was strongly problem-centered and team members only exchanged knowledge that was relevant for solving a particular problem. In formal interactions the focus was on creating a common knowledge base in the sense of an even distribution of general project information and overall project goals and not on creating common meaning. However, previous studies took the context in which the mechanisms are implemented and the practices are carried out as given, without considering the potentially detrimental effects of environmental or internal changes on the effectivity of knowledge integration over time. As Grant (1996, p. 115) stipulated, situational characteristics affect the appropriateness and relative expenditures of different knowledge integration mechanisms. He argues that, with increasing task uncertainty and task complexity, dependence on highly-interactive non-routine coordination mechanisms increases (Grant, 1996, p. 116). These effects could also be observed in the present study. Environmental uncertainty and task novelty were found to exceed the limit of effect of the support mechanisms and thereby increased the use of dialogue-based knowledge integration

Table 1: Integrating knowledge in dynamic environments

Current view	Neglected issues	Revised view
Depth of knowledge exchange		
Structural support mechanisms substitute for deep-level knowledge exchange between specialists	The level of uncertainty may change within the course of a project	Disruptions trigger changes in the mode and depth of knowledge integration within the course of a project, temporarily increasing the need for deep-level knowledge exchange among experts
	Coordination and collaboration demands of teams change over time	Effectiveness of structural support mechanisms varies over the course of a project, depending on the project phase, the project context, and the quality of teamwork
Locus of knowledge integration		
Most studies examine either individual, team, or organizational-level knowledge integration	The multilevel nature of knowledge integration	The dynamically changing degree of uncertainty determines the primary locus of knowledge integration → High uncertainty: group-level → Low uncertainty: individual-level
Breakdowns in the knowledge integration process		
Are triggered by epistemic uncertainty and lead to temporary intensifications of collaboration in integrating knowledge	Breakdowns may be caused by smaller events that disrupt the normal, taken-for-granted flow of practice	The knowledge integration process may be directly disrupted by uncertainty/novelty and indirectly by team internal conflicts for a limited time span
	Consequences beyond the changing nature of collaboration may be accompanied by breakdowns	Disruptions may lead to temporary changes in the nature of collaboration as well as in the characteristics of coordination

practices at the group-level that aimed at jointly developing meaning and maintaining innovative performance in ambiguous environments. Furthermore, in studying the two agile teams, I found factors beyond task characteristics that might disrupt the effectivity of routine knowledge integration mechanisms and practices. As shown, internal conflicts potentially interrupt the effects of the support mechanisms on the knowledge integration process. To restore their effectiveness, conflict resolution techniques, in which the interests of the conflicting parties were discussed, and an agreement was sought, were increasingly applied. These insights partly support the propositions of the cross-learning perspective, suggesting that individuals from different areas of expertise need to deeply engage with each other's knowledge, i.e. meanings, interests, and attitudes, to arrive at a common understanding that enables the integration of their knowledge (e.g. Carlile, 2004). Thus, the present study integrates insights of the specialization and the cross-learning perspective, in showing that certain internal and external disruptive factors trigger changes in the mode and depth of knowledge integration, temporarily increasing the need for deep-level knowledge exchange among experts. As outlined in the results section, the disruptive factors in my model increase the need for intense dialogical knowledge exchange for the time the factors persist, but once uncertainty, novelty or conflicts diminish, the practices rather quickly change back to the routine way of knowledge sharing that is aided by support mechanisms. It follows that the effectiveness of structural support mechanisms varies over the course of a project, depending on the project phase, the project context, and the quality of teamwork.

Second, this master's thesis adds empirical insights on the multi-level nature of the knowledge integration process and the dynamic changes in the locus of knowledge integration by showing how individual-level and group-level knowledge integration practices interact and mutually influence each other. Grant (1996, pp. 112–113) proposes that knowledge creation is an individual activity and that organizational knowledge is created through the interactions of individuals, thus implying the central role of the individual in integrating diverse strands of knowledge. In general, individual-oriented perspectives on knowledge creation posit that "individuals are the primary locus of knowledge" and therefore should be the basis for any attempt of understanding organizational knowledge creation and other knowledge processes (Felin & Hesterly, 2007, p. 197). While modelling the individual cognitive processes that underly individual knowledge integration was out of the scope of this thesis, I observed that a central component of individual work in the projects was the integration of new information with existing individual

knowledge stocks. Depending on the intensity of knowledge exchange in the phases of interaction the demands on individual knowledge integration, i.e. information-processing and sensemaking, fluctuated over the course of the projects. Furthermore, extant research adopting a process perspective on knowledge integration, proposes that the locus of integration varies over time. For example, Bruns (2013, p. 67) differentiates between expert practices, coordination practices, and collaborative practices. His process model of coordination in cross-domain collaboration depicts how team members swap between shared and domain-specific practices. In the context of new product development, Enberg et al. (2006, p. 158) also found that knowledge integration in teams happens through an iterative process of acting (alone) and interacting (with others). Similarly, Mengis et al. (2018, p. 601) found that the scientists in their study worked alone a considerable amount of time, with only short interactions if problems arose. However, "epistemic breakdowns", causing epistemic uncertainty, triggered adaptions of knowledge integration practices in the team of scientists. The primary mode of teamwork shifted from "working together-alone" with a focus on coordination to "drawing distinctions dialogically" as the breakdown occurred, to "working together-alone" again albeit with a focus on cooperation. This discovery is consistent with findings of other authors, implying that novelty and uncertainty effect the intensity of knowledge sharing in cross-functional teams (e.g. Majchrzak et al., 2012; Schmickl & Kieser, 2008). In line with previous studies and models, the process of knowledge integration across areas of expertise proposed here iterates between individual work and teamwork. In particular, the model shows that the process of knowledge integration in agile new product development teams iterates between interactions in which knowledge sharing and joint problem-solving take place and individual work, in which team members integrate the information and knowledge they gathered and processed in the interaction phases in their individual contributions. As opposed to the model of Mengis et al. (2018), the present process model takes into account the formal and repeating coordination elements inherent in new product development. In doing so, not only external factors, like uncertainty or novelty were identified to trigger changes in knowledge integration practices, but also internal conflicts that arise from absence in meetings, poor planning and preparation, silo mentality, and goal ambiguity, were found to change the intensity of knowledge exchange in the agile product development teams and thereby the primary locus of knowledge integration. Thus, triggers of change in coordination and collaboration practices do not necessarily stem from major epistemic breakdowns, but from everyday project ups and downs and violations of the expected way of working, which leads me to the final contribution of my study.

So, third and finally, this master's thesis enriches our understanding of the nature and consequences of breakdowns or disruptions in the knowledge integration process. Defined as "disruptions of the normal, taken-for-granted flow of practice when things don't go as expected" (Lok & Rond, 2013, p. 186), temporary breakdowns in sociomaterial practices are at the center of interest in studies that aim at theorizing through practical rationality (Sandberg & Tsoukas, 2011, p. 347). In investigating the dynamics of routines, Deken, Carlile, Berends, and Lauche (2016, p. 673) showed how routine work can break down in novel settings when significant differences in actors' understandings of ostensive patterns surface. Actors responded to these breakdowns through iterative episodes of routine work. In his papers on barriers to knowledge integration, Carlile (2002, 2004) already suggested that differences in knowledge, meaning and interests among actors represent boundaries that impede the integration of knowledge and become more severe as interdependencies become increasingly unknown. In introducing the concept of breakdowns to the study of interdisciplinary knowledge integration, Mengis et al. (2018) achieved similar results. The authors found that knowledge integration requires switching between different knowledge integration practices over time, which is particularly salient in light of epistemic breakdowns that are triggered by unsettling events that shake persisting understandings. The authors emphasize that in such cases, dealing with coordination issues is insufficient to maintain knowledge integration, rather collaborators need to engage in a dialogic process to handle the epistemic uncertainty they face (Mengis et al., 2018, p. 607). In a similar vein, uncertainty and novelty led to a disruption of the knowledge integration routines in the present study by overstraining the support mechanisms and increasing the need to jointly create meaning. Team members temporarily relied on group-level practices and POT decision-making to cope with these breakdowns. Consequently, the data presented here support the suggestion of Mengis et al. (2018, p. 608) that breakdowns play a critical role in temporarily changing the nature of collaboration. However, the breakdowns or disruptions in my study also effectuated a shift in decision-making and structural adaptions, thus additionally indicating temporary changes in the characteristics of coordination. Furthermore, as already discussed, not only uncertainty and novelty but also conflicts triggered changes in the knowledge integration process of the two agile teams under study, albeit in an indirect way. Silo mentality, goal ambiguity, poor meeting preparation and absence in meetings caused conflicts that were found to impair the substitutive effect of the support mechanisms, thereby unsettling the routine practices of knowledge integration. These conflicts surfaced differences (Deken et al., 2016) in interests and expectations of roles and responsibilities that ultimately led to breakdowns of the support mechanisms rather than the knowledge integration process itself. Thus, the model developed in this master's thesis enriches our knowledge about the factors that might disrupt knowledge integration with a team internal perspective that prior research in the field has neglected.

5.2. Boundary conditions and suggestions for future research

The findings of this study have to be seen in light of some limitations. The first boundary condition of the study arises

from its design. Due to the grounded theory approach with its explorative nature of the research questions and due to accessibility, a single case was chosen for the study. While single-case studies allow for detailed qualitative descriptions of natural situations under considerations of context, the ability to draw generalizations to other cases is limited, as data are subjective to a great extent and causal relationships cannot be readily established. However, the aim of this study was to generalize the findings to theory (Yin, 2003, p. 38). Thus, to be able to analyze the knowledge integration processes in the project teams in-depth, the limited generalizability of the findings to other cases was accepted. Consequently, future research is needed to test the proposed model. Moreover, due to time constraints of the author the interviews were conducted within a time span of three weeks, not allowing to record changes in expectations, attitudes, or mood of the interviewees over time. While the questions posed in the interviews were retrospective in nature and aimed at aiding the interviewees in reconstructing past events, the answers could be biased by the outcome, positive or negative, of these events. Future research should therefore conduct longitudinal studies to avoid contextual bias and be able to adequately account for causes for and results of changes in the process of knowledge integration.

The second boundary condition is due to selection and accessibility of interview partners. While an agile team consists of three different roles, the focus in this thesis was on the Work Team. Interviews with two POT members were cancelled due to time constraints and overall, the number of interviews with Work Team members exceeded those with POT members because of easier access. The findings may thus be biased by a deeper engagement with the issues mentioned by Work Team members and lacking a management perspective. For further research in this area, it is therefore advisable to expand the number of interviews and to include several perspectives from different roles. However, as prior empirical research suggests that leadership plays a significant role in knowledge processes (see Krogh, Nonaka, & Rechsteiner, 2012 for a review), I at least tried to superficially reflect on the potential effects of project management and leadership on the knowledge integration process. The data in the present study indicate that the locus of knowledge integration may shift from the individual work team members to the Product Owner Team under situations of uncertainty, as team members increasingly demand decisions by the POT. Thus, future research on the process of knowledge integration in agile new product development teams should be more responsive to the management and leadership role of the POT in knowledge processes. Furthermore, it would be interesting to elaborate more on how POT members handle the high information load in speedy decision-making. The data in this study imply that POT members are aware of their limited rationality and instead rely on gut feeling and the way things are presented to them in making decisions under time pressure.

A third boundary condition is the lack of attention on factors that might disrupt individual-level knowledge integration that arose as a result of the outshining results on the group-level. As already outlined, the team members are confronted with a lot of information in the formal sprint meetings, which can lead to information overload, especially when environmental uncertainty or task novelty are high. Excess information poses heavy demands on individuals' information-processing capacities and may overstrain their cognitive abilities (e.g. Kieser, 2001, p. 244), prompting them to focus increasingly on their own work and blanking out any other information that has no direct effect on the task to complete. Thus, information overload might impede cross-functional knowledge integration by forcing individual team members to isolate themselves and disregard less relevant information to maintain their cognitive capacity, even if the overlooked information could be useful and enrich individual problem-solving. Future research should pay more attention to the possible disruptions of individual-level knowledge integration and their implications for the process of knowledge integration. In general, future research should adopt a multi-level perspective in studying knowledge integration to account for the reciprocal effects between individual, group, and even organizational-level knowledge integration. For example, differences in the individual cognitive capacities of team members might influence the effective integration of new knowledge at the group-level (Felin & Hesterly, 2007, p. 212).

5.3. Practical implications

Effective knowledge integration across functions and areas of expertise is an important success factor of agile teamwork. In creating an innovation promotive climate and mindset, the agile way of working offers advantages over traditional forms of project management, if managed thoroughly. From the insights of this empirical study on the process of knowledge integration, some practical implications for companies planning to establish or already utilizing agile teams in their product development can be derived. The central suggestion that arises from the present thesis is that effectiveness and efficiency of the knowledge integration process can be influenced by actively managing the internal factors that tend to erode the effects of support mechanisms. This may be achieved by taking different measures. First, to reduce the internal conflicts that may lead to a disruption in the knowledge integration process, the tendency of team members to absent themselves from meetings due to resource scarcity should be reduced. While it is important to carry out the agile ceremonies strictly in the implementation phase in order to develop a kind of routine and promote the agile mindset, in later phases it is just as important to maintain flexibility by adapting the intensity of the agile methods to the present requirements of the team. The efficiency and effectiveness of formal interactions can vary over the course of a project, depending on the project phase, the project context, and the quality of teamwork. Therefore, the meeting intensity should always be adapted to the current needs of the team to better manage resources. Second, verbal knowledge exchange in meetings may be substituted with a better documentation

system to avoid conflicts that arise from a lack of knowledge. For example, the PowerPoint presentation of the DEMO could be used as record of the sprint transitions, so that team members that were unable to attend a meeting can be kept up-to-date, without additional dialogic effort. Precondition for the virtue of this approach are detailed reports on solutions or problems that are comprehensible without further explanations. Thus, team members would need to put more effort in setting up the presentation. A third measure could be to limit the involvement of team members in agile projects. The time spent in meetings represents a considerable resource expenditure for both experts and POT members that are involved in multiple projects. Absence and unpreparedness of team members might be reduced by providing them with more time through a limitation of project engagements. In addition, it is important to note that the agile methodology may not be appropriate for all kinds of projects. Development projects that are only concerned with small improvements and correction of defects that resemble more of routine work, often do not need the intense collaboration between different departments that comes along with agile project management. For these kinds of projects, it is advisable to only use individual methods from the agile toolbox, such as KANBAN to save time resources. However, in uncertain and novel contexts, in concept phases, and other phases were close coordination and collaboration are necessary, agile product development can achieve decisive advantages over conventional project management methods by promoting the exchange between departments and thus paving the way to higher innovation performance.

5.4. Conclusion

So, what is it that drives success in agile teams? From a knowledge-based view, it is the ability of team members to integrate their diverse strands of knowledge to create new knowledge, in the form of innovative new products or processes (Grant, 1996, p. 378; Iansiti & Clark, 1994, p. 557). My investigation of two agile product development teams in the manufacturing industry has shown, that the group is not necessarily at the center of the knowledge integration process, but that individual team members and their cognitive capacities play a central role in creating new knowledge. Furthermore, the study revealed that the effectiveness of both formal and informal support mechanisms is linked to contextual conditions. With the shift of the primary locus of knowledge integration from the individual to the group-level under uncertainty and novelty, mechanisms and practices beyond the routine way of knowledge integration become salient. In addition, it was shown that conflicts temporarily diminish the effect of support mechanisms, which subsequently disrupt the routine process of knowledge integration. However, actively managing potential disruptions of the knowledge integration process by flexibly adapting to externally as well as internally triggered changes in coordination and collaboration demands, can uphold innovative performance and give companies an important lead over their competition.

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