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Eva Bittner

Designing for Shared Understanding

How Collaboration Engineering can Improve Team Effectiveness of Heterogeneous Groups

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Geleitwort

Erfolgreiche Zusammenarbeit in Gruppen spielt in Zeiten wissensintensiver, verteilter und interaktiver Wertschöpfungsstrukturen eine entscheidende Rolle im Kampf um Wettbewerbsvorteile. Heterogene Akteure durch den Einsatz geeigneter Prozesse und Werkzeuge in ihrer Interaktion zu unterstützen, um gemeinsame Ziele zu erreichen und qualitativ hochwertige Ergebnisse zu erzielen, ist eine zentrale Gestaltungsaufgabe in der Wirtschaftsinformatik. Eine Schlüsselrolle für effektive Zusammenarbeit kommt hierbei der Entwicklung eines gemeinsamen Verständnisses (Shared Understanding) zu, insbesondere in sehr heterogenen Gruppen und Arbeitskontexten.

Die vorliegende Dissertationsschrift von Eva Bittner beschäftigt sich mit der Gestaltung von Kollaborationstechniken und –prozessen für Shared Understanding. Sie thematisiert Herausforderungen in der Zusammenarbeit fachlich, alters-, und erfahrungsdiverser Gruppen und entwickelt Lösungen zur systematischen Bildung von Shared Understanding. Ziel der Arbeit ist es, wiederverwendbare kollaborative Arbeitstechniken in Form eines sog. „Compound thinkLets“ zu entwickeln, die in heterogenen Gruppen zu Shared Understanding führen sollen. Hierdurch werden den Gestaltern von Kollaborationsprozessen konkrete Bausteine und Gestaltungsempfehlungen an die Hand gegeben, die genutzt werden können, um die Gruppenzusammenarbeit zu verbessern und dadurch die Gruppenleistung zu erhöhen.

Das Themenfeld der Arbeit ist in Praxis und Wissenschaft von hoher Bedeutung. Sie leistet einen äußerst relevanten theoretisch-konzeptionellen Beitrag zur Entwicklung des Konzepts Shared Understanding und zur Forschung zu Zusammenarbeit in heterogenen Gruppen. Sie zeigt erstmalig und anschaulich das große Potenzial systematischen Designs für die Bildung von Shared Understanding unter Verwendung von Kollaborationstechniken in Form des „MindMerger Compound thinkLets“ auf. Der erarbeitete Ansatz und die darin enthaltenen Konzepte können Entscheidern und insb. Collaboration Engineers und der weitergehenden Forschung als Grundlage dienen, um die aufgezeigten Potenziale zu heben. Der Arbeit von Eva Bittner wünsche ich daher die ihr gebührende Verbreitung.

Kassel, im September 2015 Univ.-Prof. Dr. Jan Marco Leimeister

Danksagung

Die vorliegende Dissertationsschrift entstand während meiner 4-jährigen Tätigkeit am Lehrstuhl für Wirtschaftsinformatik der Universität Kassel. Während dieser Zeit hat mich Zusammenarbeit nicht nur inhaltlich als Thema meiner Arbeit begleitet. Intensive Zusammenarbeit mit wichtigen Wegbegleitern hat auch die Erstellung dieser Arbeit erst möglich gemacht. Deshalb ist es jetzt an der Zeit, mich bei allen Menschen zu bedanken, die mich in den letzten Jahren inspiriert, unterstützt, begleitet und gefördert haben.

Mein Doktorvater Prof. Dr. Jan Marco Leimeister hat mich zu jeder Zeit mit seinem unerschöpflichen Fundus an thematischen und wissenschaftlichen Hinweisen zum Blick über das eigene mentale Modell hinaus ermutigt. Meinen Ko-Autoren und Kollegen am Fachgebiet danke ich für den intensiven fachlichen und persönlichen Austausch und die Aufgeschlossenheit, sich in nicht selten hitzigen Diskussionen gemeinsam hin zu neuem “Shared Understanding“ zu entwickeln. Einige dieser Wegbegleiter sind in dieser Zeit zu Freunden geworden und haben mir damit Kassel zu einer weiteren Heimat gemacht.

Ein besonderer Dank gilt nicht zuletzt meiner Familie, die diese Arbeit und meine oft unkonventionellen Ideen in allen Phasen mit jeder möglichen Unterstützung, dem notwendigen Freiraum und Rückhalt bedacht haben. Ihnen gilt mein besonderer Dank.

Kassel, im September 2015 Eva Bittner

Zusammenfassung

Problemstellung und Zielsetzung der Arbeit

Viele Aufgaben in modernen Organisationen übersteigen die Kapazität jedes Einzelnen und erfordern die Integration verschiedener Fähigkeiten. Daher arbeiten Mitarbeiter vermehrt in heterogenen Gruppen zusammen. Verschiedene Studien zeigen, dass diese heterogenen Gruppen bei komplexen Aufgaben leistungsfähiger sein können als homogene (Canon-Bowers et al. 2000; Wegge et al. 2008). Zudem ermöglicht Heterogenität in Arbeitsgruppen eine ganzheitlichere Sichtweise auf komplexe Probleme und bietet Potenziale für mehr Kreativität und gegenseitiges Lernen. Zur Nutzung der Vorteile muss jedoch eine Herausforderung überwunden werden. Diese besteht darin, dass unterschiedliche Personen verschiedene Begriffe für dieselben Dinge oder dieselben Begriffe für unterschiedliche Dinge verwenden, ihnen somit ein gemeinsames Verständnis (Shared Understanding, im Folgenden SU) fehlt. Die bisherige Forschung zum Thema Gruppenkognition hat gezeigt, dass SU eine zentrale Rolle für eine erfolgreiche Gruppenleistung spielt, da vielfach ein positiver Zusammenhang mit Teamkohäsion, Teamkollaboration, Zufriedenheit und der Qualität des Kollaborationsproduktes beobachtet werden kann (Mathieu et al. 2000; Langan-Fox et al. 2004; Hsieh 2006; Kleinsmann and Valkenburg 2008). Ein inhärenter, initialer Mangel an SU in heterogenen Gruppen kann dazu führen, dass Zusammenarbeitsprozesse ineffizient ablaufen und zu suboptimaler Leistung führen (Valkenburg and Dorst 1998; Mohammed and Dumville 2001; Darch et al. 2009).

Damit heterogene Gruppen erfolgreich zusammenarbeiten können, ist es für sie besonders wichtig, früh in der Zusammenarbeit ein SU über die gemeinsame Aufgabe und deren Lösung zu entwickeln und dadurch Wissen und Kompetenzen aggregieren zu können (Fransen et al. 2011). Die Zielsetzung dieses Promotionsvorhabens besteht daher darin, wiederverwendbare kollaborative Arbeitstechniken in Form eines compound thinkLets zu entwickeln, die in heterogenen Gruppen zur Bildung von SU führen. Dieses compound thinkLet soll von Designern von Kollaborationsprozessen genutzt werden können, um die Gruppenzusammenarbeit zu verbessern und dadurch die Gruppenleistung zu erhöhen. Während die Entwicklung von Kollaborationsprozessen in der Vergangenheit laut Briggs (2006) häufig eher Kunst als Wissenschaft und damit für Praktiker ohne tiefes Methodenwissen schwer replizierbar war, setzt sich diese Arbeit zum Ziel, Praktikern systematisch hergeleitete, dokumentierte, wiederverwendbare Techniken bereitzustellen, die verlässlich zur Entwicklung von SU in heterogenen Gruppen beitragen.

Forschungsdesign und -methodik

Die Zielsetzung der Arbeit spiegelt sich in den folgenden forschungsleitenden Fragen wider:

Im ersten Schritt ist es notwendig, die identifizierte Forschungslücke hinsichtlich der klaren Konzeptionalisierung und Operationalisierung von SU zu schließen. Forschungsfrage 1 dient dazu, basierend auf den Vorarbeiten verschiedener Disziplinen einen Forschungsrahmen für den Untersuchungsgegenstand Shared Understanding, seine Determinanten und Effekte aufzuspannen:

FF1.1: Wie kann Shared Understanding definiert und gemessen werden?

FF1.2: Was führt zur Entwicklung von Shared Understanding in heterogenen Gruppen?

Abgeleitet aus dem theoretischen Rahmen des konzeptionellen Modells befassen sich die Forschungsfragen 2.1 und 2.2 mit der theoriemotivierten Entwicklung eines wiederverwendbaren compound thinkLets und seiner Implementierung in einer realweltlichen Problemsituation.

FF2.1: Wie kann die Entwicklung von Shared Understanding durch ein compound thinkLet systematisch und wiederholbar hervorgerufen und unterstützt werden?

FF2.2: Wie kann das compound thinkLet zur Ausbildung von Shared Understanding in einen Kollaborationsprozess für eine realweltliche Problemsituation eingebettet werden?

Forschungsfrage 3 dient zur Evaluation der entwickelten Artefakte.

FF3.1: Inwieweit löst der entwickelte Kollaborationsprozess das realweltliche Problem?

FF3.2: Welche Effekte hat das compound thinkLet auf die Entwicklung von Shared Understanding?

FF3.3: Inwieweit treten die im Modell für Shared Understanding erwarteten Zusammenhänge zwischen Determinanten, Shared Understanding und Effekten im realweltlichen Anwendungsfall auf?

Zur Beantwortung der forschungsleitenden Fragen folgt die vorliegende Arbeit dem Forschungsverständnis explorativer Forschung (Bortz und Döring 2006). Die Vorgehensweise explorativer Forschung erlaubt dem Forschenden, flexibel auf neue und unerwartete Ergebnisse zu reagieren. Durch ein iteratives Vorgehen und einen kontinuierlichen Lernprozess können innerhalb der explorativen Forschung bestehende Theorieansätze genutzt und neue Erkenntnisse zur Theoriebildung generiert werden (Kubicek 1977). Dieser Ansatz wurde gewählt, da für den Untersuchungsgegenstand SU ein einheitliches Konzeptverständnis sowie etablierte Theorien fehlen.

Um den Untersuchungsgegenstand in seiner Komplexität und Einbettung in die realweltliche Problemsituationen umfassend betrachten zu können, wird Aktionsforschung (Action Research, AR) als methodischer Rahmen der Arbeit gewählt. AR ist ein Ansatz der Sozialforschung, bei dem sich der Forscher aktiv an einer Intervention beteiligt, durch die zum Einen versucht wird, das soziale System zu verändern, und zum Anderen, neue Erkenntnisse über das System gewonnen werden sollen. In einem systematischen, zyklischen Prozess liegt der Fokus auf dem Verstehen und Wandeln von Zuständen in konkreten Feldsituationen. Um der dualen Zielsetzung des AR besser gerecht zu werden und die Wissenschaftlichkeit dieses Forschungsansatzes zu stärken, wird in dieser Arbeit das erweiterte AR-Modell von McKay und Marshall (2001) genutzt, bei dem eine Trennung zwischen Problemlösungs- und Forschungszyklus vorgenommen wird. Der Forschungszyklus dient zur wissenschaftlichen Exploration eines realweltlichen Problems, zum Erkenntnisgewinn über den theoretischen Forschungsrahmen und zur Beantwortung der wissenschaftlichen Forschungsfragen. Ergebnis des Forschungszyklus ist eine Theorie bzw. Theoriebausteine. In der vorliegenden Arbeit ist dies erklärende und Designtheorie zu SU, seinen Determinanten und Effekten. Der Problemlösungszyklus zielt auf die Lösung einer konkreten realweltlichen Problemsituation (Wissensintegration und -transfer in heterogenen Teams) mithilfe einer Intervention unter Verwendung einer Problemlösungsmethode (hier: Collaboration Engineering (Briggs et al. 2006)). Ergebnis des Problemlösungszyklus sind Artefakte (im vorliegenden Fall das Kollaborationsprozessdesign und das MindMerger compound thinkLet). Die explorative Natur des AR-Designs bringt Einschränkungen in der Übertragbarkeit der Erkenntnisse mit sich. Der Gefahr des Over-Fitting auf die konkrete Problemsituation wird durch Einsatz von Collaboration Engineering zur Sicherstellung der Wiederholbarkeit und Übertragbarkeit der Techniken bestmöglich begegnet. Ergänzend wurde ein Studentenexperiment zur Evaluation des MindMerger compound thinkLet durchgeführt. Die Kombination aus verschiedenen Methoden der Datenerhebung und -analyse wirkt der mangelnden Verfügbarkeit von Kontrollgruppen und eingeschränkten Kontrollmöglichkeiten über Störgrößen im realweltlichen Pilotierungsumfeld entgegen. Die Triangulation sorgt zudem dafür, der Komplexität des Untersuchungsgegenstandes gerecht zu werden.

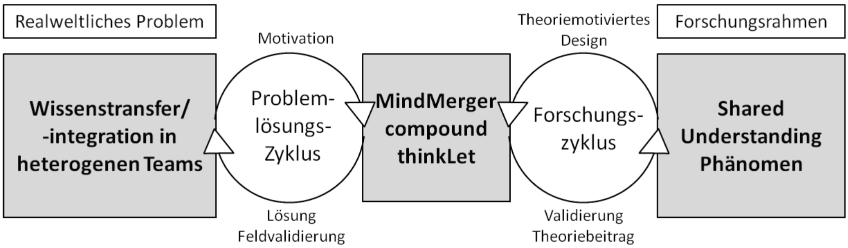

Abb. 1. Zusammenhang von realweltlichem Problem, Design und Forschungsrahmen
Quelle: eigene Darstellung basierend auf McKay und Marshall (2001)

Ergebnisse

Die kumulative Dissertation basiert auf sieben zentralen Publikationen, die jeweils spezifische Beiträge zur Beantwortung der forschungsleitenden Fragen leisten.

Dem zentralen Aktionsforschungsprojekt vorgelagerte Untersuchungen dienen der Entwicklung des initialen Forschungsrahmens und der Definition des Untersuchungsgegenstandes Shared Understanding.

Die Bedeutung von SU in Arbeitsgruppen verdeutlicht ***Publikation 1*** (Kapitel 5). Dort wird gezeigt, dass fehlendes SU zu Ineffizienzen in der untersuchten interdisziplinären Zusammenarbeit heterogener Fachexperten in einem Requirements Engineering Prozess führt. Aus dieser Publikation wird der Bedarf nach systematischen Kollaborationstechniken für SU deutlich. Zudem können aus dem beobachteten Unterschied zwischen Mutual und Shared Understanding und den identifizierten Ursachen für fehlendes SU Erkenntnisse für die Konzeptualisierung von SU abgeleitet werden (Beitrag zur Beantwortung von ***FF 1.1***).

Publikation 2 (Kapitel 6) definiert SU auf Grundlage einer Literaturanalyse und identifiziert Construction, Co-Construction und Constructive Conflict als zu betrachtende Einflussfaktoren auf die Entwicklung von SU in Teams. Außerdem stellt die Publikation Messinstrumente für die betrachteten Konstrukte zusammen (***FF 1.1 und FF 1.2***). Das konzeptionelle Modell auf Basis von van den Bossche et al. (2011) wird zur Ableitung von Designrichtlinien für die Ausgestaltung eines compound thinkLets für SU herangezogen. Die Publikation trägt desweiteren zur Beantwortung von ***FF 2.1*** bei, indem eine initiale Version des MindMerger compound thinkLet entwickelt und in einem IT-gestützten Anforderungsvereinbarungsworkshop validiert wird. Die Erkenntnisse dienen als erster Machbarkeitsnachweis für die folgende Intervention im AR-Projekt.

Im Kern der Arbeit steht ein zentrales AR-Projekt zur Wissensintegration in altersdiversen Arbeitsgruppen von Facharbeitern in der Automobilbranche, in dem das MindMerger compound thinkLet iterativ weiterentwickelt, und eingebettet in ein Workshopkonzept in der realweltlichen Anwendung, validiert wird. ***Publikation 3*** (Kapitel 7) beschreibt umfassend das methodische Vorgehen im AR-Projekt, die Weiterentwicklung des MindMerger compound thinkLets in den sechs durchgeführten AR-Zyklen (***FF 2.1***) sowie die Einbettung des MindMergers in ein umfassendes, 3-tägiges Workshopprozessdesign für Wissenstransfer zwischen Experten und Novizen (***FF 2.2***).

Publikation 4 (Kapitel 8) führt die konzeptionellen Ergebnisse aus den Publikationen 2 und 3 zusammen und bietet neben einer Darstellung des Aktionsforschungsprojektes im Gesamtüberblick eine umfangreiche Evaluation im Feld. **FF 3.1** kann im Rahmen von Publikation 4 vollständig abgedeckt werden. Eine umfassende Evaluation des gemeinsamen Wissens, der Zufriedenheit und des Gruppenzusammenhalts wurde vor und nach der Durchführung des Workshopprozesses durchgeführt. Hieraus wird u. a. erkenntlich, dass nach dem Workshopprozess das gemeinsame Wissen über den Arbeitsprozess in der Selbsteinschätzung der Teilnehmer in jeder Gruppe deutlich angestiegen ist. Auch andere wichtige Kennzahlen, wie z.B. die Bereitschaft, mit den Gruppenmitgliedern weiterhin zusammenzuarbeiten, verbesserten sich. Ferner konnte gezeigt werden, dass der Kollaborationsprozess mit dem MindMerger compound thinkLet im Anwendungsfall den Wissenstransfer zwischen Experten und Novizen unterstützt (***FF 3.1***). Zudem ergab die Evaluation, dass die teilnehmenden Teams Construction, Co-Construction und Constructive Conflict-Verhalten zeigen und, dass nach Anwendung des MindMerger compound thinkLets ein SU-Anstieg erzielt wird

(***FF 3.2***). Daneben enthält diese Publikation eine ausführliche Dokumentation des finalisierten MindMerger compound thinkLets und der darin genutzten modifizierten thinkLets, um sie für andere Collaboration Engineering Forscher und Praktiker unmittelbar nutzbar zu machen. Erkenntnisse aus den sechs Aktionsforschungszyklen dienen zum Einen zur Verbesserung des Designs, zum Anderen aber auch zur Erweiterung der Wissensbasis zum Forschungsgegenstand Shared Understanding. So enthält Publikation 4 u.a. eine weiterentwickelte Definition von SU als "*the degree to which people concur on the value of properties, the interpretation of concepts and the mental models of cause and effect with respect to an object of understanding*" (Bittner and Leimeister 2014).

Um die Erkenntnisse aus dem AR-Projekt zu komplementieren und ***FF 3.2*** und ***FF 3.3*** abschließend beantworten zu können, wurde ein zusätzliches Studierenden-experiment durchgeführt (***Publikation 5,*** Kapitel 9). Während der Fokus im AR-Projekt auf der umfassenden Exploration reicher und komplexer realweltlicher Informationen lag, konnten im Experiment die angenommenen Kausalzusammenhänge unter kontrollierten Bedingungen untersucht werden. Im Rahmen dieses Experiments war es möglich, zu zeigen, dass im gewählten Kontext der Einsatz des compound thinkLets in der Treatmentgruppe zu mehr Team Learning Mechanismen, höherem SU und besserer Teameffektivität führte als unstrukturierte Zusammenarbeit in der Kontrollgruppe.

Während sich die vorangegangenen Publikationen schwerpunktmäßig mit SU und dem Design von Techniken für SU beschäftigen, wird das AR-Projekt nachgelagert aus Wissensmanagementperspektive betrachtet. In Form einer Fallstudie wird das Pilotierungsprojekt zunächst aus wissenschaftlicher Wissensmanagementperspektive (***Publikation 6,*** Kapitel 10) analysiert. Diese Publikation leistet einen Forschungsbeitrag zum Verständnis des Wissenstransfers und des kollaborativen Lernens von Experten und Novizen. Die Ergebnisse zeigen, dass Experten und Novizen während des Wissenstransferprozesses mit unterschiedlichen Herausforderungen konfrontiert sind und, dass sich die Herausforderungen über die Dauer der Zusammenarbeit hinweg verändern. Neben einer Strukturierung dieser Herausforderungen werden Lösungsstrategien aus den Beobachtungen der Fallstudie und Annahmen für Anschlussforschung im Wissensmanagement abgeleitet.

Publikation 7 (Kapitel 11) bereitet die Fallstudie für die Zielgruppe der Wissensmanagement-Praxis auf. Der Ablauf der dreitägigen Wissenstransfer-

Workshopserie wird hier ausführlich beschrieben und anhand von Beispielen aus der Pilotierung illustriert. Diese Publikation stellt somit als Kernbeitrag den Workshopprozesss zum Wissenstransfer in heterogenen Arbeitsgruppen zum Transfer in die betriebliche Praxis bereit.

Theoretischer Beitrag

Diese Arbeit leistet theoretische Beiträge zur SU und Collaboration Engineering Forschung auf mehreren Ebenen: Zunächst trägt die konzeptionelle und empirischen Exploration zu einer geschärften Definition des Konstrukts SU, seiner Determinanten und Effekte bei. Diese Erkenntnisse können als Grundlage zur Entwicklung prüfbarer Hypothesen für Ursachen-Wirkungszusammenhänge um SU dienen. Erfahrungen aus der Konzeption und Verwendung der Messinstrumente ermöglichen die Identifikation von Forschungslücken auf dem Weg zu einem einheitlichen, umfassenden Messansatz für SU.

Desweiteren zeigt diese Arbeit auf, wie die Entwicklung von SU in Gruppen systematisch und wiederholbar unterstützt werden kann. Sie wendet hierzu die Vorgehensweisen des Collaboration Engineering an. Ergebnisse in Form von Gestaltungsrichtlinien und eines wiederverwendbaren Gestaltungsmusters (MindMerger compound thinkLet) geben für den Einsatz in vergleichbaren Kollaborationssituationen Techniken für das Kollaborationsmuster „clarify“ an die Hand. Sie sind damit anschlussfähig an bisherige Collaboration Engineering Forschung und leisten einen wissenschaftlichen Beitrag zu den mit SU verbundenen Forschungsgebieten Gruppenkognition und Wissensmanagement.

Praktischer Beitrag

Die zentralen praktischen Beiträge dieser Arbeit ergeben sich aus der Entwicklung und Dokumentation des MindMerger compound thinkLet und des Kollaborationsprozesses zur Verbesserung des Wissenstransfers in heterogenen Gruppen. Dieser ist auch für andere Organisationen nutzbar, die vor ähnlichen Herausforderungen im Bezug auf den Wissenstransfer und die Zusammenarbeit in heterogenen Gruppen stehen. Das MindMerger compound thinkLet als Kernergebnis ist so dokumentiert, dass es in vergleichbaren Kollaborationsprozessen implementiert und zur Entwicklung von Shared Understanding in heterogenen Gruppen von Praktikern eingesetzt werden kann. Es kann damit einen Beitrag zur Verbesserung der Teameffektivität in heterogenen Arbeitsgruppen leisten.

Ausblick

Zukünftige Forschung im Anschluss an diese Dissertation sollte sich mit dem Einsatz der entwickelten Techniken in alternativen Anwendungsfeldern beschäftigen, um die Übertragbarkeit und den Nutzen des MindMerger compound thinkLet und des Kollaborationsprozesses zum Wissenstransfer weiter zu belegen. Auf Basis der Erkenntnisse zu SU und seinen Determinanten können weitere Kollaborationstechniken zur Unterstützung des „clarify" Kollaborationsmusters entwickelt werden, die zusätzliche Anwendungsbereiche abdecken (z.B. Kollaboration in virtuellen Teams oder Mass Collaboration). Die in dieser Arbeit explorativ abgeleiteten Ursachen-Wirkungs-Annahmen sollten empirisch überprüft werden. Das hier erarbeitete Messmodell für SU, seine Determinanten und Effekte sollte anhand der identifizierten Verbesserungspotentiale weiterentwickelt und validiert werden.

Stichworte: Collaboration Engineering, Shared Understanding, Gruppenkognition, Action Research, Wissensmanagement, thinkLet.

Abstract

Shared Understanding (SU) has been claimed crucial for effective collaboration by researchers and practitioners, especially in heterogeneous groups. Nevertheless, SU and its formation are largely unexplored. Research on SU and related constructs has focused so far on describing the phenomenon itself, its effects or antecedents. It was out of scope of these studies how these antecedents could be reflected in design choices for collaboration systems. On the other hand, design of collaborative work practices is still more of an art than science in such fuzzy, multifaceted fields as SU construction. Success or failure of a group to increase their SU in a collaborative situation used to depend strongly on the intuition of the collaboration process designer or the ability of a skillful facilitator. This thesis addresses this gap by exploring the phenomenon SU, developing and validating a reusable collaboration technique to evoke the construction of SU in heterogeneous groups. After conceptualizing SU I apply an action research approach under the use of Collaboration Engineering to derive a validated collaboration process module (compound thinkLet "MindMerger") to systematically support heterogeneous work groups in building SU. The MindMerger development has been grounded in existing research on SU and own considerations. Design guidelines and a working definition of SU describe the research frame. The compound thinkLet has been derived from the design guidelines, documented in a thinkLet notation and implemented in the action research setting. I conducted a large scale action research project at a German car manufacturing company to iteratively improve and validate the MindMerger. The evaluation indicates that with the use of MindMerger, team learning behaviors occur, and SU of the tasks in complex work processes increases among experience diverse tool and dye makers. Further evaluation in an experimental setting complements the evaluation. Additionally, the action research project has been analyzed from a theoretical and practical knowledge management perspective in the form of a case study. Thus, the validated compound thinkLet MindMerger provides designers of collaborative work practices with a reusable module of activities to solve clarification issues in group work early on. Furthermore, insights from the field study contribute to the knowledge base of SU research by conceptualizing the largely unexplored phenomenon of SU and its formation.

Key words: Collaboration Engineering, Shared Understanding, Group Cognition, Action Research, Knowledge Management

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Abbreviations

A	Activity
AR	Action Research
CoP	Communities of Practice
DSR	Design Science Research
exp.	Experts (experienced participants)
FF	Forschungsfrage
Fig.	Figure
FPM	Facilitation Process Model
G	Guideline
GSS	Group Support System
IS	Information Systems
IT	Information Technology
Max.	Maximum
Min.	Minimum
non-exp.	Non-experts (less experienced participants)
PLS	Partial Least Squares
RE	Requirements Engineering
RN	Requirements Negotiation
RQ	Research Question
Sig.	Significance
SPSS	Statistical Package for the Social Sciences
SU	Shared Understanding

1 Introduction

Collaborative work in heterogeneous work groups has become common practice in modern organizations, as many tasks exceed the capabilities of individuals. People collaborate when complex challenges require the integration of diverse knowledge or various experts' perspectives (Fischer 2000; Langan-Fox et al. 2004). Such challenges can range from requirements negotiation processes for software development that need to account e.g., for technical, legal, and user requirements (Hoffmann et al. 2013) to collaborative business model development within cross-disciplinary start-up teams. Heterogeneity in work groups results e.g. from differences in personality traits, educational background, job experience, interests and personal goals, age, gender and cultural influences. Trends related to demographic change such as age gaps in the workforce or increasing cultural diversity enforce the necessity to cope with and derive advantage from heterogeneity.

Several studies show that heterogeneous groups can outperform homogeneous groups on complex tasks under certain conditions (Canon-Bowers et al. 2000; Wegge et al. 2008). Heterogeneity in groups can e.g., contribute to gaining a broader perspective on the problem, enhance creativity and foster mutual learning. However, heterogeneity comes with challenges for collaborative work practices, if people rely on different words or mental models. A lack of common language, shared mental models and SU can lead to inefficiencies and failure of collaboration among diverse actors (Valkenburg and Dorst 1998; Mohammed and Dumville 2001; Darch et al. 2009).

In order to work together more effectively, it is of special importance for heterogeneous groups to develop a sufficient level of Shared Understanding on the group task and the way to solve it. Prior research in the field of group cognition found evidence for the crucial role of Shared Understanding for successful collaboration. Shared Understanding in a group may among others be positively related to better team cohesion, enhanced collaborative interaction, and increased satisfaction of team members as well as higher quality group products (Mathieu et al. 2000; Langan-Fox et al. 2004; Hsieh 2006; Kleinsmann and Valkenburg 2008). Team members however may need explicit support to integrate their diverse knowledge and perspectives (Fransen et al. 2011).

There are two major fields of research that emerge from the challenge of Shared Understanding construction:

First of all, designers of collaborative work practices need structured support on how to design for Shared Understanding in order to improve team effectiveness. According to Briggs (2006), the development of collaboration processes used to be more art than science in the past and was thus hardly reusable by practitioners without comprehensive methodological knowledge. Especially for clarification tasks, little documented support is available in literature. Guidelines and reusable collaboration techniques should thus be developed that can be used by collaboration engineers and facilitators of collaborative work to recurringly and reliably evoke Shared Understanding development in heterogeneous work groups.

Second, in order to allow for more systematic design and shed light on the still fuzzy phenomenon Shared Understanding, exploration of clarification processes in real world settings is required. As group cognition is a complex notion and comprehensive theoretical models are lacking to explain Shared Understanding development, it is crucial to develop a broader picture of the factors that foster or hinder Shared Understanding construction.

This thesis aims at contributing to both fields by exploring and adding to the conceptual understanding of Shared Understanding and its determinants as well as by providing a technique for Shared Understanding construction. Exploration and development are executed in three different settings to account for a broad range of clarification challenges:

- An action research study for knowledge integration among age and experience diverse tool and dye makers in a large automotive company.
- A software requirements negotiation process in a multidisciplinary development team.
- A collaborative learning task under experimental conditions with ad hoc first term IS student teams.

With an iteration of theory and practice, exploration and design, new insights for building a theory on Shared Understanding have been derived and the MindMerger compound thinkLet for Shared Understanding construction has been developed and continuously improved.

In particular, the following questions guided the publications included in this thesis:

Based on prior research from different disciplines, research question 1 aims at constructing an initial knowledge frame on Shared Understanding, its determinants and effects:

RQ 1.1: What is Shared Understanding and how can it be measured?

RQ 1.2: What are determinants of Shared Understanding development in heterogeneous groups?

Building on the conceptual model derived from the theoretical knowledge base, research question 2 addresses the need for reusable techniques for Shared Understanding by developing and instantiating the MindMerger compound thinkLet for Shared Understanding.

RQ 2.1: How can Shared Understanding development be systematically evoked and supported by a reusable collaboration technique (compound thinkLet)?

RQ 2.2: How can the compound thinkLet for Shared Understanding be implemented in a collaboration process design to solve a real world problem situation?

Research question 3 aims at evaluating the MindMerger compound thinkLet and whether it solves the real world problem, as well as the underlying assumptions on determinants and effects of Shared Understanding.

RQ 3.1: In how far does the developed collaborative work practice solve the real world problem in its practical application?

RQ 3.2: In how far does the MindMerger compound thinkLet affect Shared Understanding development?

RQ 3.3: In how far do the assumed relationships between determinants, Shared Understanding and effects manifest in the situations under study?

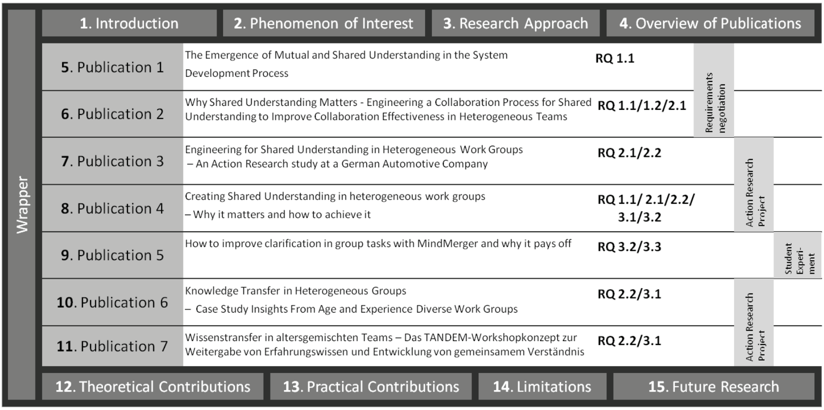

Figure 1. Dissertation scope and research questions
Source: Own presentation

The research questions are answered in a cumulative dissertation, composed of seven main publications. The rest of the thesis is structured as follows:

First, the central terms are defined and Shared Understanding is distinguished from related constructs. Second, the AR frame underlying this thesis and the research methodology are outlined. Section four gives an overview of the publications within this dissertation. In sections five to eleven, I present the publications of this thesis and their specific results. Afterwards, the contributions to theory and practice as well as the limitations of this work are summarized. Finally, I conclude with an outlook on future research that can build on the previously discussed findings.

Figure 1 shows the structure of this thesis with the wrapper (chapters 1 – 4 and 12 – 15) comprising the frame for publications 1 – 7 (chapters 5 – 11). For each publication, the graphic displays the RQs it mainly contributed to as well as the study it is associated with (AR, requirements negotiation or student experiment).

2 Definition of Phenomenon of Interest Shared Understanding

In order to understand the work within this thesis, the underlying understanding of the phenomenon of interest deserves clarification. In prior literature, Shared Understanding and related terms (e.g., shared mental models, team mental models, group cognition, sense making, etc.) have been used and defined in different ways in different research streams.

An initial working definition for my investigations had been derived from this literature base in publication 2 (chapter 6). In this paper, I defined Shared Understanding "as an ability to coordinate behaviors towards common goals or objectives ("meaning in use" or action perspective) of multiple agents within a group (group level) based on mutual knowledge, beliefs and assumptions (content & structure) on the task, the group, the process or the tools and technologies used (scope/object perspective) which may change through the course of the group work process due to various influence factors and impacts group work processes and outcomes". (Bittner and Leimeister 2013)

However, this definition has evolved as a result of the action research project. One contribution of this thesis is an advanced conceptualization of Shared Understanding. The refined definition of Shared Understanding is "*the degree to which people concur on the value of properties, the interpretation of concepts and the mental models of cause and effect with respect to an object of understanding*". (Bittner and Leimeister 2014)

In contrast to the initial definition, this new definition is based on shared as a resource being possessed jointly by several people rather than shared as distribution of resources, which means the overlap of understanding among team members. It stresses the assumption that the object of understanding can be of various structures and contents, e.g., the group task, process, or technology used. "The value of properties, the interpretation of concepts and the mental models of cause and effect" (Bittner and Leimeister 2014) have been included into the definition as domains of Shared Understanding. They are derived from research on the "build commitment" pattern of collaboration that has identified five categories of sources of a lack in consensus, which are closely related to domains for Shared Understanding: differences in the meaning assigned to words, different mental models, information differences, differences in individual goals and differences in taste (Briggs et al.

2005; Kolfschoten et al. 2009). The first three categories are also common domains of Shared Understanding (see Bittner and Leimeister (2014) for an explanation of this choice). Shared meaning is the degree to which group members interpret a concept in the same of a number of possible ways. Shared mental models refer to the degree to which mental models of cause and effect are similar among group members. Shared information means the degree to which people in a group concur on the value of the properties of things in which they are interested.

With respect to this definition of Shared Understanding, it is important to note that Shared Understanding is seen as a dynamic state that can gradually evolve over time due to, e.g., learning. This view as a dynamic state is crucial for the assumption that Shared Understanding can be influenced by deliberate design of collaborative processes, which underlies this thesis.

3 Research Approach

As the phenomenon of interest, Shared Understanding is characterized by high complexity and no sufficient basis of explanatory research on causes and effects is available to guide collaboration design efforts (Akkerman et al. 2007), an exploratory research approach has been chosen. Exploratory research allows the researcher to include unexpected observations, examine the phenomenon of interest in a holistic way and react flexibly to new insights. A combination of different (in particular qualitative) data collection methods serves the needs of exploration best. With data triangulation, advantages of different methods can be combined and a broader perspective can be taken.

This thesis is based on action research as the framing exploratory research approach. Action research is a social science approach, where the researcher gets actively involved in the intervention to change a social system, while at the same time trying to gain new insights on the system (Baskerville 1999). In a systematic cyclical process the aim of action research lies in understanding and improving specific field situations. In the extended action research model of McKay and Marshall (2001) problem solving cycle and research cycle are distinguished, in order to cope with the dual goal of action research and answer the critics to lack scientific rigor.

The research cycle aims to advance the theoretical knowledge on the research frame and answer the research questions. The result of the research cycles is a theory or building blocks for theory. Within the scope of this thesis, theoretical knowledge to explain Shared Understanding construction as well as design theory for Shared Understanding should be developed. The problem solving cycle aims at solving a specific real world problem with an intervention under use of a specific problem solving method. The result of the problem solving cycle is an artifact (in the present case the MindMerger compound thinkLet and the collaboration process it is embedded in). This dual view is consistent with Briggs´ (2006) request for a separation of theory building research (derived from answering the research questions) and artifact (subject to engineering questions).

To solve the described problem and investigate Shared Understanding, the five typical action research phases are passed through in an iterative way. First, in the diagnosis phase, the phenomenon of interest, an initial research frame and the real world problem are defined. This phase addresses the motivation of the real world problem (covered in publication 1) and the literature analysis and development of an initial conceptualization of Shared Understanding (publication 2). In the following publications, the initial knowledge is complemented by insights from further action research iterations to answer RQ 1. In the second phase (action planning), the MindMerger thinkLet is developed (RQ 2.1). The first version of the thinkLet is presented in publication 2 and iteratively adapted during the field AR cycles (publications 3&4).

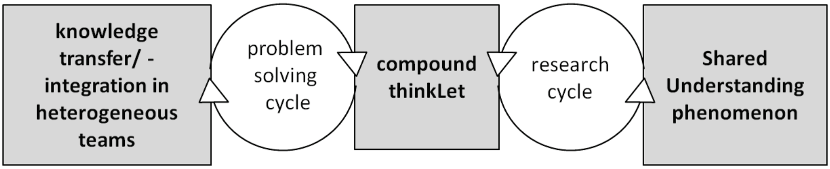

Figure 2. Dual cycle action research approach
Source: Own representation based on (McKay and Marshall 2001)

Third, the thinkLet is implemented in specific instantiations within collaboration processes (action taking). Action taking is executed in several iterations. Application in a requirements elicitation workshop serves as a first proof of concept validation (publication 2). The main implementation is done in the knowledge transfer workshop project (publication 3&4) in six iterative pilot workshop series, complemented by implementation in a student experiment (publication 5). RQ 2.2 is in the focus of this phase. All efforts have been continually evaluated concerning their ability to solve the real world problem (RQ3.1), the ability of the MindMerger to evoke the team learning behaviors it is designed to (RQ 3.2), and the causal model for Shared Understanding (RQ 3.3). To complement the rich data from the main action research field setting with more controllable experimental data, publication 5 provides an additional experiment for evaluation. New insights are constantly added (specifying learning) to the knowledge base on Shared Understanding, the MindMerger compound thinkLet, as well as to the understanding of the real world problem solution of knowledge transfer in heterogeneous teams (publications 6 and 7).

4 Overview of Publications

This dissertation is based on three guiding research questions, which are answered in seven publications and subsidiary papers (see complete bibliography in the appendix). The publications constitute the following sections of this thesis (table 1). In this section, I present a short overview on the content of all seven publications.

No.	Publication	Chapter
1	Hoffmann, A.; Bittner, E. A. C. & Leimeister, J. M. (2013): The Emergence of Mutual and Shared Understanding in the System Development Process. In: Requirements Engineering: Foundation for Software Quality, Lecture Notes in Computer Science. Editors: Doerr, J. & Opdahl, A. L. Publisher: Springer Verlag, Essen, Germany. Year: 2013. Pages: 174-189.	5
2	Bittner, E. A. C. & Leimeister, J. M. (2013): Why Shared Understanding Matters - Engineering a Collaboration Process for Shared Understanding to Improve Collaboration Effectiveness in Heterogeneous Teams. In: Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS), Maui, USA.	6
3	Bittner, E. A. C.; Hoffmann, A. & Leimeister, J. M. (2013): Engineering for Shared Understanding in Heterogeneous Work Groups - An Action Research study at a German Automotive Company. In: Proceedings of the 13th Meeting on Group Decision and Negotiation (GDN) 2013, Stockholm, Sweden.	7
4	Bittner, E. A. C. & Leimeister, J. M. (2014): Creating Shared Understanding in heterogeneous work groups - Why it matters and how to achieve it. In: Journal of Management Information Systems (JMIS), Number: 1, Vol. 31, Year: 2014, 111-143.	8
5	Bittner, E. A. C.; Hoffmann, A. & Leimeister, J. M. (2014): How to improve clarification in group tasks with MindMerger and why it pays off. Submitted to: 12. Internationale Tagung Wirtschaftsinformatik (WI, under review).	9
6	Bittner, E. A. C. & Leimeister, J. M.: Integrating Knowledge in Diverse Groups – Case Study Insights on Shared Understanding Construction. Submitted to Journal of Knowledge Management (under review).	10
7	Bittner, E. A. C. (2014): Wissenstransfer in altersgemischten Teams – Das TANDEM-Workshopkonzept zur Weitergabe von Erfahrungswissen und Entwicklung von gemeinsamem Verständnis. Working Paper.	11

Table 1. Overview of publications
Source: Own representation

Publication 1

Hoffmann, A.; Bittner, E. A. C. & Leimeister, J. M. (2013): The Emergence of Mutual and Shared Understanding in the System Development Process. In: Requirements Engineering: Foundation for Software Quality, Lecture Notes in Computer Science. Editors: Doerr, J. & Opdahl, A. L. Publisher: Springer Verlag, Essen, Germany. Year: 2013. Pages: 174-189.

The first publication (chapter 5) motivates the importance of Shared Understanding research and contributes to framing the real world problem as well as the phenomenon of interest for the following action research study. In this publication, a common field for challenges in Shared Understanding is analyzed:

Interdisciplinary requirements engineering, where different stakeholders need to understand how other disciplines think and work (mutual understanding) and agree on the system they develop (Shared Understanding) in order to collaborate effectively. In this paper the extent and forms of (lacking) mutual understanding according to the periods in the process of conceptual change are analysed. Therefore, the communication of a multidisciplinary team while developing a mobile application is examined. Although the team tried to resolve differences in meaning early on by applying approaches for clarification, questions for consolidation, exploration and elaboration occurred at different points in time throughout the process. Even when artifacts were already agreed upon, the development team encountered lack of mutual understanding to underlying concepts or relationships. A revised Shared Understanding led to adjustments of the artifacts and thus hampered the process. Taking the insights from this investigation into consideration, I conclude a need for research that explores ways of systematically building mutual and Shared Understanding in the development process in heterogeneous teams. By introducing a scheme of different sources for a lack of Shared Understanding and studying them in a real world situation, this first publication helps to conceptualize the phenomenon of interest, Shared Understanding (RQ1.1).

Publication 2

Bittner, E. A. C. & Leimeister, J. M. (2013): Why Shared Understanding Matters - Engineering a Collaboration Process for Shared Understanding to Improve Collaboration Effectiveness in Heterogeneous Teams. In: Proceedings of the *46th Hawaii International Conference on System Sciences (HICSS), Maui, Hawaii.*

The second publication (chapter 6) addresses RQ 1 by giving an overview of prior research on Shared Understanding and related concepts. Based on a literature review, a working definition of Shared Understanding for future investigations is derived. Furthermore, van den Bossche et. al.'s (2011) model of team learning behaviors is chosen as an initial research frame to guide design activities. This publication also contributes to answering RQ 2.1 through theory driven development of an initial version of the MindMerger compound thinkLet, a systematic, reusable process that should support groups to converge towards a Shared Understanding of a task to be then able to collaborate more effectively and efficiently. To achieve the proposed goal, a collaboration process is developed from theory based design guidelines, including activities for individual (1) and collaborative construction of meaning (2) as well as constructive conflict resolution (3). We ground our work in group cognition research and apply a Collaboration Engineering approach (de Vreede et al. 2009). We validate the process design in a computer-aided requirements elicitation workshop with experts from different professional backgrounds. This validation serves as a first proof of concept for the intervention in the following main action research study in publications 3 and 4.

Publication 3

Bittner, E. A. C.; Hoffmann, A. & Leimeister, J. M. (2013): Engineering for Shared Understanding in Heterogeneous Work Groups - An Action Research study at a German Automotive Company. In: Proceedings of the 13th Meeting on *Group Decision and Negotiation (GDN) 2013, Stockholm, Sweden.*

Publication 3 (chapter 0) presents the action research approach used in the study with experience diverse tool and dye-makers at a German car manufacturing company to build a Shared Understanding among diverse group members and to integrate knowledge of different actors successfully. The paper describes the instantiation and iterative development of the MindMerger compound thinkLet with respect to the specific real world problem it should help to solve. In this setting, the MindMerger is used to build a Shared Understanding of the sequence of activities in complex work processes. As participants showed the intended team learning behaviors and an increase in Shared Understanding, insights for RQ 2.1 and 2.2 could be derived. In particular, the MindMerger design has been advanced based on the insights from the field study.

Publication 4

Bittner, E. A. C. & Leimeister, J. M. (2014): Creating Shared Understanding in heterogeneous work groups - Why it matters and how to achieve it. In: Journal of Management Information Systems (JMIS), Number: 1, Vol. 31, Year: 2014, 111-143.

This publication (chapter 8) links insights from publication 2 and 3 by spanning the action research project from a comprehensive viewpoint. Based on the theory driven design efforts of publication 2 and the iterative exploration in a real world setting in publication 3, a refined conceptualization of the construct Shared Understanding is derived in this paper (RQ 1.1). The Collaboration Engineering approach to derive the MindMerger compound thinkLet to systematically support heterogeneous work groups in building Shared Understanding is described. Furthermore, the publication focuses on analyzing the large scale action research study at a German car manufacturing company. In particular, we analyze the interrelation of the MindMerger use, the observed team learning behaviors and Shared Understanding as well as team effectiveness measured in the field setting. Detailed analysis of the rich data and resulting design implications from the action research cycles with experience diverse tool and dye makers are provided in this paper. The evaluation indicates that with the use of MindMerger, team learning behaviors occur, and Shared Understanding of the tasks in complex work processes increases among experience diverse tool and dye makers (RQ 3.1). Thus, publication 4 provides designers of collaborative work practices with a validated, reusable module of activities to solve clarification issues in group work early on. In the logic of action research, exploratory findings from observing the pilot project iteratively circle back to advancing the knowledge base on Shared Understanding. Two main gaps for further research within the scope of this thesis are identified in publication 4: First, the MindMerger compound thinkLet deserves additional experimental evaluation concerning its impact on team learning behaviors and Shared Understanding, as only limited causal conclusions can be drawn from the action research explorations. This need is addressed in publication 5. Second, rich data was collected in the pilot setting, which exceeds the scope of the MindMerger and Shared Understanding research. Therefore, in publications 6 and 7, I discuss the organizational knowledge management case from a holistic perspective to derive insights for comparable knowledge management challenges.

Publication 5

Bittner, E. A. C., Hoffmann, A. & Leimeister J. M.: How to improve clarification in group tasks with MindMerger and why it pays off. Working Paper.

While publication 4 mainly focuses on evaluating the MindMerger compound thinkLet for its ability to solve the real world problem (RQ 3.1), publication 5 (chapter 9) addresses RQ 3.2 and RQ 3.2 in detail. Prior explanatory research on Shared Understanding mainly describes factors that favor the occurrence of Shared Understanding. In publication 5, however, we investigate whether Shared Understanding can be deliberately evoked by collaboration process design and if this effort pays off in team effectiveness. Therefore we present the results of the evaluation of the MindMerger compound thinkLet. In contrast to the main action research field study presented before, this evaluation is executed under controlled experimental conditions with student groups working on a standardized task. In this setting, we could split participants randomly into a treatment and a control group to draw more reliable causal conclusions and exclude more external influences than in the rich action research project. In the student experiment, teams guided by the MindMerger showed more team learning behaviors for clarification and higher degrees of Shared Understanding than did their team members with unstructured collaboration. Under the controlled conditions at hand, participants that used the MindMerger thinkLet also produced better group products in expert assessment and reported more team effectiveness in their own perception. Thus, publication 5 supports and complements the evaluation findings from paper 4 to answer research question 3.

Publication 6

Bittner, E. A. C. & Leimeister J. M : Integrating Knowledge in Diverse Groups – Case Study Insights on Shared Understanding Construction. Working Paper.

Publication 6 (chapter 10) exceeds the scope of the MindMerger compound thinkLet and Shared Understanding research, by providing a broader knowledge management perspective on the action research field setting. While part of the organizational knowledge management case on the one hand served as an application field for the MindMerger intervention (one section of the first of three workshops for each team), it provided much broader insights on collaborative interaction and learning in heterogeneous groups. Supporting knowledge transfer in age- and experience diverse work groups requires a deep understanding of the interaction mechanisms, challenges and solution approaches that these teams face. Therefore, we report case study insights from the real world pilot project in a large automotive company where a three day workshop process was introduced to support knowledge integration between experts and novices, who had the task to document complex work processes in learning material for new colleagues. Findings indicate that experts and novices face different types of issues in Shared Understanding in their interaction, and that challenges change throughout the course of collaboration. We contribute a collection of recurring challenges for designers of collaborative work practices and make recommendations for solving them. From this exploratory case study, we derive implications for Shared Understanding and knowledge transfer research to be validated in comparable knowledge management challenges. The contributions of publication 6 fit the findings of this thesis into the larger picture of organizational knowledge management and identify starting points for the development of more techniques like the MindMerger compound thinkLet to support clarification and knowledge integration in heterogeneous groups.

Publication 7

Bittner, E. A. C. (2014): Wissenstransfer in altersgemischten Teams – Das TANDEM-Workshopkonzept zur Weitergabe von Erfahrungswissen und Entwicklung von gemeinsamem Verständnis. Working Paper.

Später publiziert als:

Bittner, E. A. C. & Leimeister, J. M. (2015): Das TANDEM-Konzept zur Unterstützung des Wissenstransfers in altersdiversen Arbeitsgruppen. In: Exploring Demographics - Transdisziplinäre Perspektiven zur Innovationsfähigkeit im demografischen Wandel. Jeschke, S.; Richert, A.; Hees, F. & Jooß, C.; Springer Spektrum, Wiesbaden, Germany, Year 2015, 371-382.

In line with publication 6, publication 7 (chapter 11) presents a knowledge management view of the knowledge transfer project in a large German automotive company. In contrast to the prior paper, this publication aims at a target audience of knowledge management practitioners and organizational decision makers. The goal of this publication is to document the three day workshop process for supporting knowledge integration between experts and novices in a format that allows transfer to comparable knowledge management projects in other organizations. Thus, publication 7 describes each of the three workshop days in great detail, and provides examples from the pilot implementation. In order to make the workshop process design reproducible by practitioners, instructions, work orders and pictures of exemplary intermediate and end results are presented. Furthermore, I discuss lessons learned from the pilot project and organizational conditions that need to be considered when using the workshop process design. This paper makes a contribution to knowledge management practice by providing designers of knowledge transfer practices with a role model process for the common challenge of integrating complex knowledge in age diverse or otherwise heterogeneous work groups.

5 The Emergence of Mutual and Shared Understanding in the System Development Process

Axel Hoffmann, Eva Alice Christiane Bittner, Jan Marco Leimeister

Abstract. In interdisciplinary requirements engineering, stakeholders need to understand how other disciplines think and work (mutual understanding) and agree on the system they develop (Shared Understanding) in order to collaborate effectively. In this paper we analyse extent and forms of (lacking) mutual understanding according to the periods in the process of conceptual change. We analyse the communication of a multidisciplinary team while developing a mobile application. Although the team tried to resolve differences in meaning early on by applying approaches for clarification, questions for consolidation, exploration and elaboration occurred at different points in time throughout the process. Even when artifacts were already agreed upon, the development team explored lack of mutual understanding to underlying concepts or relationships. A revised Shared Understanding led to adjustments of the artifacts and thus hampered the process. We therefore call for research that explores ways of systematically building mutual and Shared Understanding in the development process.

Keywords: Mutual Understanding, Shared Understanding, Requirements Engineering, System Development Process

Please quote as: Hoffmann, A.; Bittner, E. A. C. & Leimeister, J. M. (2013): The Emergence of Mutual and Shared Understanding in the System Development Process. In: Requirements Engineering: Foundation for Software Quality, Lecture Notes in Computer Science. Editors: Doerr, J. & Opdahl, A. L. Publisher: Springer Verlag, Essen, Germany. Year: 2013. Pages: 174-189.

5.1 Introduction

It is widely acknowledged that mutual and Shared Understanding between stakeholders is important for successful development projects (Tan 1994). This is especially true for the requirement engineering activities (Aranda et al. 2010; Berkovich et al. 2012; Corvera Charaf et al. 2012). Stakeholders need to understand what other stakeholders are able to understand and work with, and they need to deliver artifacts that can be used by others (Baxter and Sommerville 2011). Further, the stakeholders need to agree on and determine the system that is built in subsequent activities.

When developing socio-technical systems many stakeholders from various backgrounds are involved in requirement engineering activities. This interdisciplinary development enhances the importance of a Shared Understanding of the system and the requirements. While the stakeholders involved usually do not need to be experts in all fields tackled by the development project, “they have to be able to integrate their knowledge bases in a sensible manner” (Kleinsmann et al. 2010). Coming from different disciplines, actors might - without noticing - be using the same words for different concepts or different words for the same concepts (de Vreede et al. 2009). They might be unaware of unshared individual knowledge crucial for completing the task successfully (lack of mutual understanding). Or even if they are aware of differences in knowledge and understanding, they might not agree on a shared perspective at an early stage (lack of Shared Understanding). This can lead to substantial losses in efficiency in collaboration processes and suboptimal outcomes (Valkenburg and Dorst 1998; Mohammed and Dumville 2001; Darch et al. 2009). Necessary late changes to requirements are likely to be followed by evitable rework and time-consuming changes to the whole system. Unfortunately, assessing whether a Shared Understanding of the system exists is not trivial. Various ideas and views only become evident in the course of the project, making a potential adjustment of the system and its requirements necessary.

As we identify Shared Understanding as a key success factor of interdisciplinary development projects and as a dynamic state that changes through interaction and communication, we aim to examine the interactive process of building Shared Understanding throughout a real world software development project. This paper explores in which stages of the development project a lack of mutual or Shared Understanding is discovered and how this is resolved. Different sources of disagreement require different strategies to resolve them (Kolfschoten et al. 2009), and an understanding of the causes of lacking Shared Understanding is also necessary. Therefore, we further investigate which different types of conflicts are discovered at which phases. Thus, we show particular types of understanding that should be improved by using additional effort. To achieve this, we examine the evolution of Shared Understanding on properties and requirements of a mobile application in an interdisciplinary development project by focusing on development artifacts and the correlating communication. We categorise questions and hints that are raised by stakeholders according to the process of conceptual change. Consolidation and exploration questions indicate effort to gain mutual understanding. Elaboration questions try to reconcile different understandings or resolve conflicts.

This paper has been structured in the following manner. First, a short explanation of what mutual and Shared Understanding will be presented, as well as how they can be achieved in development projects. Subsequently, the research design of the case study will be described, including the team, the development approach, data collection and data analysis. Further, we report and discuss the results. The paper closes with limitations and implications for further research.

5.2 Mutual and Shared Understanding in Development Projects

We define Shared Understanding as the ability of multiple agents within a group to coordinate behaviors towards common goals or objectives based on mutual knowledge, beliefs and assumptions on the task, as well as the group, the process or the tools and technologies used that may change throughout the course of the group work process and may impact group work processes and outcomes (Bittner and Leimeister 2013). This definition implies a dynamic (process) view of Shared Understanding. Mohammed and Dumville (2001) note, that "in order for a team to achieve a shared, organized understanding of knowledge about key elements in the relevant environment, changes in the knowledge and/or behavior of team members will most likely occur. Therefore, group learning plays a significant role in the development, modification, and reinforcement of mental models" (Mohammed and Dumville 2001). The definition of Shared Understanding is furthermore based on a "meaning in use" point of view, which refers to coordinated action based on some resource being possessed jointly by several people. This means that it is a necessary but still insufficient prerequisite for each stakeholder to know how other disciplines think and work, and recognise where different understanding occurs (mutual understanding) in order to reach Shared Understanding.

However, mutual understanding does not yet mean that group members share a common viewpoint or are able to act in a coordinated manner. As our definition of Shared Understanding involves a "meaning in use" aspect, mutual agreement on one perspective is thus necessary to achieve Shared Understanding. For example, it is not enough to have a collection of requirements the different stakeholders hold, since in the course of development not only differences and conflicts among those requirements may hinder goal directed action but also different actors may prioritize and omit different requirements in their activities. The development team needs to negotiate and agree on a shared and non-conflicting mental model they want to follow.

Briggs et al. (2005) and Kolfschoten et al. (2009) distinguish between five potential sources of disagreement in collaborative requirements engineering. Three of these (differences of meaning, mental models and information) fall into the core of our concept of Shared Understanding, as they refer to a lack of mutual knowledge, beliefs or assumptions. They are mainly related to a certain proposal or proposal-outcome judgement (Briggs et al. 2005; Kolfschoten et al. 2009). "Differences of meaning occur when the same words or labels are used for different concepts or when different words or labels are used for the same concept" (Kolfschoten et al. 2009). Differences of mental models occur on the level of cause and effect chains rather than on individual concepts. Both can be based on knowledge, beliefs and assumption, whereas differences of information are defined as conflicting knowledge or knowledge that not all of the stakeholders have.

When these sources of disagreement are revealed through asking clarification questions and communicating different views, mutual understanding evolves. If stakeholders agree on a common perspective on meaning, information and mental models, a Shared Understanding can be reached. The other two sources of disagreement are about conflicting goals or taste and might require other consensus building strategies that focus on negotiation rather than on clarification, as they exist due to differences in outcome-instrumentality judgments (Briggs et al. 2005; Kolfschoten et al. 2009). They do not result from differences in understanding, but mutually exclusive individual goals that hinder stakeholders from committing to a group goal or action.

A lot of effort has been spent on providing techniques to enhance Shared Understanding in the requirements engineering activities (see (Sutcliffe 2010) for a discussion of the contribution of different representations to the RE activities). For example, goals (Dardenne et al. 1993), application scenarios (Jarke et al. 1998; Weidenhaupt et al. 1998; Haumer et al. 2002) and requirements negotiation with EasyWinWin (Gruenbacher 2000; Briggs and Grünbacher 2002) are proposed to support a Shared Understanding between stakeholders. We focus on the effectiveness and results of the combination of these three techniques to clarify the requirements in a multidisciplinary project team. There is some effort in the community to categorize and detect clarification events in written communication about requirements (Knauss et al. 2012). In our research, we distinguish between different types of clarification questions to get an idea if, and how, a mutual and Shared Understanding is reached, as well as which sources of disagreement are revealed.

5.3 Research Method

A case study to investigate the emergence of mutual and Shared Understanding in the system development process was performed in the research project VENUS. In this case study, a project was carried out in which a multidisciplinary team developed the mobile application Meet-U. This is depicted in the next section, followed by a description of the multidisciplinary project team. The development process including the approaches to fostering mutual and Shared Understanding is further shown. After the description of the case study, we describe the data collection and data analyses.

5.3.1 The Mobile Application Meet-U

In the case study the development of the mobile application Meet-U was attended. The idea for Meet-U had already been developed and realised in a technically oriented prototype (Comes et al. 2011). The goal of Meet-U is to support users with regards to organising and arranging meetings with their own friends. Meet-U assists them in planning meetings or events on the way to the location or even at an actual meeting or event.

In greater detail, users can register for public events or create private meetings to which they can invite other people. Further, users can provide personal information about themselves or their interests in order to receive recommendations for events and other users with similar interests. If a user would like to attend a public event, Meet-U creates recommendations using the provided data and interests upon request. When creating private events, Meet-U recommends contacts upon request that are determined by using the settings for the event, as well as the personal interests listed by the users. Depending upon the current location of the users, they are reminded of the beginning time of the event. In addition, Meet-U provides navigation services. On-site, the event host can offer services that Meet-U recognises and integrates into the graphical user interface, such as ticket services or site plans.

5.3.2 The Multidisciplinary Development Team

For the development of Meet-U, socio-technical concerns and requirements (Geihs et al. 2012) should be taken into account. They are related to legal conformance, usability and trust. Legal conformance refers to the inclusion of legal requirements. Usability wants to ensure that users can handle and interact with the application. Trust refers to the intention or willingness of users to be vulnerable to important actions of the system without the ability to monitor or control the system (Lee and See 2004).

To consider the socio-technical requirements, a multidisciplinary development team consisting of four developers and three domain experts was formed; more precisely, a legal expert, an expert for perceived user trust and user acceptance, and a usability expert were involved. The most experienced developer was responsible for the management of the project. The first author functioned as an observer in the development team and attended the project meetings. The team members had known each other for at least one year due to the cooperation in the research project.

5.3.3 Development Approach

The development of Meet-U took place from October 2011 until April 2012 (there was a four week Christmas break). To assess the socio-technical requirements, the whole development was carried out by the multidisciplinary team: demand analysis, requirements engineering, conceptual design, software design, implementation and evaluation. Figure 1 illustrates the phases that are briefly summarised in the following sections (see Comes et al. (2012) for details and a discussion of the results regarding the development approach). Due to the fact that the development was integrated in a research project, the requirements were repeatedly reflected upon and discussed anew by the development team until September 2012.

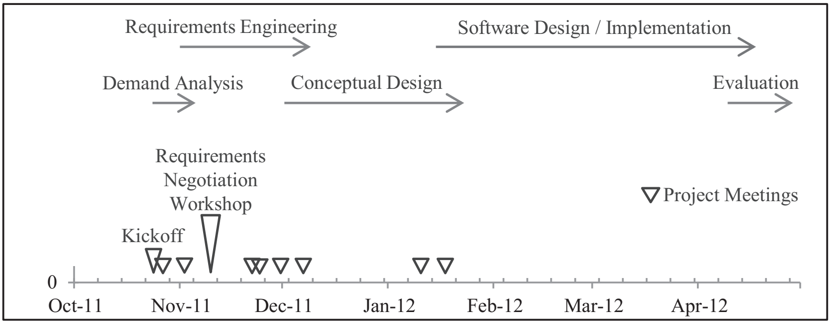

Figure 1. Phases of the Development Project
Source: Own representation

In order to enable the collaboration of stakeholders in the first phase of development beginning with a kick-off on the 25th of October 2011, the team created goals (Dardenne et al. 1993) and application scenarios (Haumer et al. 2002) to establish an interdisciplinary vision of the mobile application. Scenarios are a particular kind of design artifact intended to facilitate Shared Understanding of the target system, its interaction with users and subject domain, and its larger context (Jarke et al. 1998). Goals and scenarios are widely used in requirements engineering as a common basis for communication, and are well suited to resolve misunderstandings with stakeholders from different disciplines (Weidenhaupt et al. 1998; Pohl 2008). They also enforce interdisciplinary learning (Weidenhaupt et al. 1998). Therefore, the application goals were outlined from the perspective of users, after which they were refined for the application scenarios.

Further, persona were created as archetypical representatives of user groups in order to make the scenarios as realistic and comprehensible as possible for all involved stakeholders with specific, future users. In an additional activity, a business model was developed as an extension to the scenarios in order to assess the marketability. A validation of the extended scenarios was carried out with potential users to reveal incorrect assumptions about users and the application. Later, the scenarios were used as a reference by stakeholders during the development project in order to retain focus on the goals selected from the user perspective.

In requirements engineering, the stakeholders collected, analysed and documented the requirements. A computer assisted requirements negotiation workshop following EasyWinWin (Gruenbacher 2000) was used to agree upon all requirements that were collected in advance. EasyWinWin "is based on the WinWin requirements negotiation model and helps a team of stakeholders to gain a better and more thorough understanding of the problem and supports co-operative learning about other's viewpoints" (Briggs and Grünbacher 2002). The workshop took place at the 10th and 11th of November 2011.

In a first step, the stakeholders evaluated the comprehensibility of the requirements, created a glossary of terms and definitions, and adjusted the requirements. The requirements deemed important by one stakeholder were transferred to a new list if all stakeholders agreed that they had understood the requirement (in order to avoid redundancies). In accordance with EasyWinWin, the requirements were then rated by the stakeholders in terms of importance and ease of realisation. In the next step, stakeholders could express concerns regarding certain requirements in the tool. In another round, proposals for solutions for the issues were collected, before a conjoint agreement was reached by means of a group discussion. After the requirements negotiation, the requirements were structured and added to the requirements documentation.

In the concept design, different kinds of design artifacts intended to facilitate Shared Understanding were used. First, use cases were developed. The multidisciplinary team verified the use cases in order to ensure a correct requirement transformation. In the second step, the data and functional elements of the application were described. Thus, all information provided for the user and every operation the user could make were identified. Flowcharts were employed to graphically illustrate the operation steps and the corresponding data and functional elements. Further, the structure of the user interface was depicted in a sitemap. The fourth step consisted of deriving a first graphical design with a functionless prototype of the user interface. All stakeholders received the produced artifacts and were asked to check if the requirements had been fulfilled.

The resulting artifacts, agreed upon in an interdisciplinary manner, functioned as a working basis for the developers in the implementation phase. The application concept was implemented in an iterative process. Next, the created prototypes were assessed by experts with regards to whether the previously defined requirements were taken into account during the realisation. This examination enabled changes to be made to the application concept that were integrated into the next iteration. In addition, the component functions developed in the process were evaluated from a user perspective.

The concluding evaluation of the usage aimed at assessing the functionality as well as the social compatibility of the system. It was experimentally tested with real users in as realistic application surroundings as possible in order to see whether the requirements had been fulfilled. See Söllner et al. (2012) for more information concerning the realisation and selected evaluation results.

5.3.4 Data Collection

In order to analyse the communication in the development project, quantitative data collection and evaluation methods were selected. We conducted a document analysis for the collection of data. The objects of investigation were: the description of the application scenarios in six versions; the business model in three versions; the list of requirements in six versions; four versions of the use cases; the workflows and screens designs in four versions; as well as minutes of the ten project meetings. All documents as well as complementing communication were exchanged in 611 emails between members of the development team for the duration of the whole project using a project specific mailing list. These emails were the data basis for our assessment. The documents contained, apart from the actual content, distinguished changes of the pre-version, as well as comments and notes made by the involved stakeholders. The project language was German. During the collection of data, the first author functioned as an observer in the meetings of the development team.

5.3.5 Data Analysis

The evaluation of the documents was accomplished with the aid of a quantitative content analysis. To reduce the amount of data, the 611 emails were screened through, and relevant emails with development artifacts or textual contributions were extracted. The 183 resulting emails and documents were transformed to PDF files and stored in ATLAS.ti 6.2, providing support for manual qualitative coding. As we were interested in the emergence of mutual and Shared Understanding, we conducted the data analysis in three steps.

In the first step, 330 comments (one or more sentences from emails or annotations of the documents) were marked that contained questions, raised issues or indicated different understandings about a requirement. We refer to these comments as *questions* in the remainder of the text. One of the authors marked the questions in the ATLAS.ti by reading all emails twice.

In the second step, we analysed the questions of the team members. To distinguish the questions, we used the classification that was proposed by Watts et al. (1997) to classify questions of understanding according to the periods in the process of conceptual change. Conceptual change occurs when participants either consolidate their current understanding, explore beyond their current knowledge to expand it or elaborate on it to challenge and test their framework of understanding (Watts et al. 1997). Consolidation, exploration and elaboration are all indicative of changes in the current conceptual thinking of the person asking those questions. For elaboration question that reconcile different understandings or resolve conflicts, in the third step, we used subcategories containing the key sources of conflicts proposed by Briggs et al. (2005) and Kolfschoten et al. (2009). The subcategories are differences of meaning, differences of mental models, differences in information, mutually exclusive individual goals and differences of taste (Table 1).

Category	Subcategory	Explanation
Consolidation	-	Confirm explanations and consolidate new ideas (mutual understanding)
Exploration	-	Seek to expand knowledge and test constructs (mutual understanding)
Elaboration		Reconcile different understandings, resolve conflicts (Shared Understanding)
	Differences of meaning	The same words are used for different concepts or different words are used for the same concept
	Differences of mental model	Different understandings of the means for achieving desired outcomes, or of sequences of cause and effect
	Differences in information	stakeholders do not have the same information, or one stakeholder has information that other stakeholders do not have
	Mutually exclusive individual goals	Difference of interests or values
	Differences of taste	There is no rational conflict of stakes or values but rather one of taste

Table 1. Categories and subcategories used for coding
Source: Own representation

Two graduate students coded the questions according the categories with ATLAS.ti. They were provided with explanations and examples and received 30 minutes of training. For the coding, one student needed 5 hours and 15 minutes and the other needed 5 hours and 30 minutes. The students could, and did, ask the first author if they faced difficulties. Questions that were not assigned to the same category by both students were discussed and assigned to a category by two of the authors.

5.4 Results

This section reports the number of questions assigned to the different categories and subcategories. We divided the development project into three stages that are important for mutual and Shared Understanding in requirements engineering: the stage before the requirement negotiation where the scenario is developed and the requirements are collected, the requirements negotiation workshop which is designed to reveal misunderstandings and reach an agreement about the system and its requirements, and the time after this agreement. In the next section, we first report the results of the assignment to the categories consolidation, exploration and elaboration. The elaboration questions are further analysed in the second subsection.

5.4.1 Questions for Consolidation, Exploration and Elaboration

To analyse the emergence of mutual and Shared Understanding, we categorised the questions and pointers in the documents according to the periods in the process of conceptual change. Questions for consolidation and exploration indicate a lack of mutual understanding; questions for elaboration indicate a lack of Shared Understanding.

	Before RN	**During RN**	**After RN**	**Total**
Consolidation	20	24	74	118
Exploration	16	34	54	104
Elaboration	22	51	35	108
Total	58	109	163	330

Table 2. Questions before, during and after requirements negotiation (RN)
Source: Own representation

Table 2 shows that there are a similar number of questions in each category and that one third of all questions were raised in the requirements negotiation workshop. Further, most conflicts could be elaborated upon before the end of the requirements negotiation, but there were more questions regarding the mutual understanding after requirements negotiation than there were in the combined before and during the requirements negotiation.

Figure 2 shows the emergence of questions regarding mutual and Shared Understanding. Especially in late November, December and January, after requirements negotiation (including a four week Christmas break), team members raised questions for consolidation and exploration almost continuously.

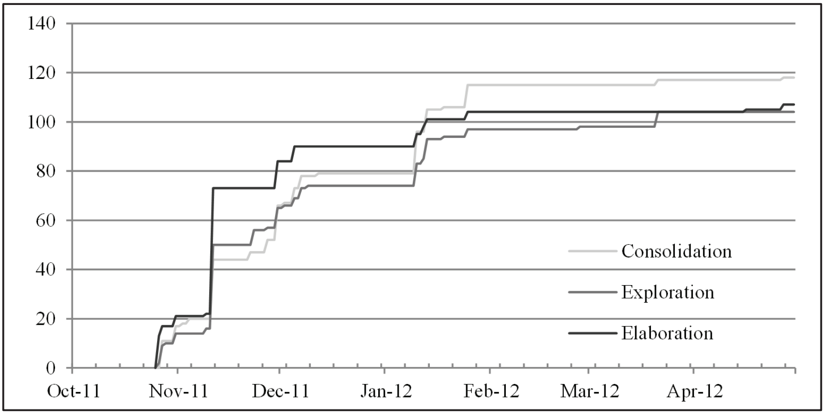

Figure 2. Cumulative quantity of questions according to the process of conceptual change throughout the development project
Source: Own representation

This indicated that the stakeholders had the same goal but understood the requirement differently. This conflict was assigned to the category difference of mental model. The incidents of lacking Shared Understanding/differences in mental models concerning the requirements were especially critical, as system specification and development had already been executed at this point in time, based on the requirements, which had been agreed upon but had obviously not been fully understood.

5.4.2 Elaborated Conflicts

To analyse the conflicts that were revealed in the development project, we categorised the elaboration questions according to their key differences. We found that most conflicts during the whole development project dealt with different goals of stakeholders that, in most cases, were connected to their disciplinary background. For example, the legal expert wanted the user to agree on every function using personal data. In contrast, the usability expert did not want to interrupt the user while executing a task with the application. Almost the same quantity could be identified for the differences of mental models. Fewer conflicts belonged to differences of meaning, conflicting information and differences of taste (Table 3). Most conflicts regarding goals were elaborated in the requirements negotiation workshop, but differences of mental model were mostly revealed later in the project, which is critical, based on our assumption that revealing conflicts in the proposal-outcome judgement should be the basis for all further negotiation.

	Before RN	During RN	After RN	Total
Differences of Meaning	5	3	4	12
Difference of Mental Model	12	8	17	37
Conflicting Information	1	5	2	8
Mutually Exclusive Individual Goals	3	33	8	44
Differences of Taste	1	2	4	7
Totals	22	51	35	108

Table 3. Elaborated conflicts before, during and after requirements negotiation (RN)
Source: Own representation

Figure 3 shows that differences of mental models were revealed throughout the project. Considering the differences of meaning, most conflicts were revealed before the requirements negotiation workshop; however, similar to the conflicting information and differences of taste, there were no peaks throughout the development project. Therefore, the number of conflicts remained at a low level, in contrast to the differences of mental models and individual goals.

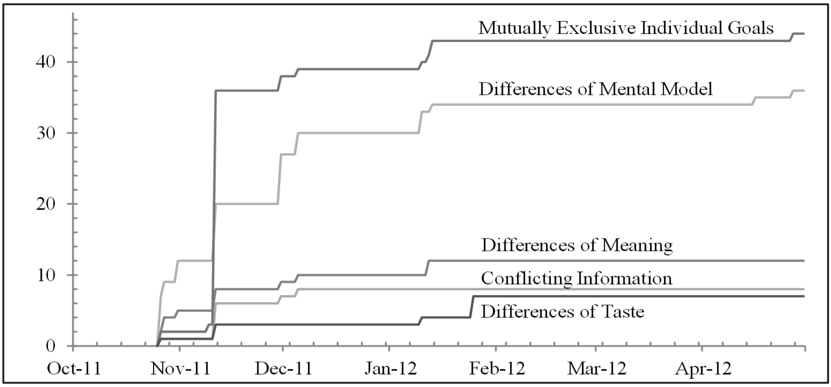

Figure 3. Cumulative quantity of conflicts revealed throughout the development project
Source: Own representation

Summarizing, a revised Shared Understanding evolved late in the development phases. This led to adjustments of the artifacts and, thus, hampered the development process.

5.5 Discussion

The aim of our study was to analyse extent and forms of (lacking) mutual and Shared Understanding and how this understanding emerges in the system development process. Further, we wanted to examine which forms of conflicts occurred and in which stages of the development process they were revealed. This section discusses the results and provides suggestions for the improvement of mutual and Shared Understanding in development projects.

We first checked the questions according to the process of conceptual change. We could find an almost equal number of questions regarding consolidation, exploration and elaboration. As shown in the results section, the mutual and Shared Understanding emerged together. There were a lot of elaboration questions among the requirements negotiation workshop, but questions regarding mutual understanding emerged evenly distributed in the project. Due to the fact that a lack of Shared Understandings can only be detected effectively if a mutual understanding exists, there should be additional effort made in the beginning of the development project that would foster mutual understanding of the multidisciplinary team (Corvera Charaf et al. 2012). This could be done, e.g., by enforcing reflection and actively introducing techniques for construction and co-construction of meaning (van den Bossche et al. 2011). Bittner et al. (2013) present a first attempt to develop reusable techniques for systematically building mutual and Shared Understanding.

To strengthen this stream of research and enlarge the set of available techniques, further research into understanding and designing mutual and Shared Understanding is thus necessary. In requirements engineering, natural language software requirement patterns (Withall 2008; Renault et al. 2009; Hoffmann et al. 2012) could help to foster a mutual understanding by using standardised, well defined and discipline independent terms and formulations. Further, the unambiguity could be fostered with a proven template that is provided by the requirement pattern.

The investigation of the elaboration questions indicated that all five types of conflicts occurred in the development project. This goes in line with Briggs et al. (2005) and Kolfschoten et al. (2009). Further, we could quantify the different categories. Most conflicts belonged to the categories' mutually exclusive individual goals und difference of mental model. While the requirements negotiation workshop was good at revealing mutually exclusive individual goals, it was insufficient for revealing differences of the mental model. Over the time of the project the differences of the mental model emerged continuously, only fostered by repeated interactions of the stakeholders. Together with the observation that there was also no concentration of consolidation and exploration questions in the requirement negotiation workshop, we assume that EasyWinWin helps to deal with conflicting goals of the stakeholders, but other approaches are necessary to foster other problems in understanding.

These issues - important to address as artifacts in the development process - are highly interrelated and build on each other. Late changes of requirements due to differences in meaning or mental models, which should have been detected and clarified early in the process, might require new negotiation efforts on goals or taste when the system has already been agreed on. We assume that in an effective requirements negotiation process, differences of understanding should be discovered as early as possible, as mutual understanding is a prerequisite for Shared Understanding.

Based on mutual understanding, a shared perspective can be negotiated. Shifts in this process of detecting and resolving sources of disagreement might require unnecessary iterative loops and delays. Thus, collaboration techniques should be applied to shift those attempts from coincidence to a systematic and reusable process. For this purpose, group model building techniques can be used or analysts should search for conflicting assumptions behind the conflicting models (Kolfschoten et al. 2009). A lack of Shared Understanding caused by differences of the mental model might also be addressed with software requirement patterns. Apart from the proven formulation of the requirement template, they can provide background information that helps other stakeholders understand the causes and estimate the effects of the requirement.

5.6 Limitations

This section summarises the threats to the validity of the work.

The internal validity of the case study could be threatened by the fact that we analysed only the written communication (including the annotated development artifacts) in the project and minutes that were taken in the meetings. The requirements negotiation workshops and the meetings were conducted in the presence of the observer but without recording of the oral communication. In the requirements negotiation workshop, the stakeholders were encouraged to write down their questions and issues through the use of the computer-based EasyWinWin. Thus, we could analyse them in detail. Although we did not prevent oral communication in the workshop or in other meetings, the focus on the written communication is a limitation of this study.

Coding the data analysis, the students reached agreement on most questions but were also faced with difficulties. Especially questions that were asked very politely to show (in subsequent discussion between the stakeholders) that there might be a conflict. These were partly assigned to consolidation or exploration. Also, they had some difficulties with questions that consolidated new ideas. If they read a question alone they had difficulty deciding if it was just a new idea or a conflict. To clarify this, the students could consult the first author that observed the development project and had attended the project meetings. All questions with such uncertainties were discussed by two of the authors before they were assigned to categories. Therefore, background knowledge of the development project was partly necessary to assign some of the questions.

Regarding external validity, the major concern is the generalizability of the results since we conducted only one case study. The case study with seven people is embedded in a research project that has distinct features such as the repeated discussion and reflection about requirements, which might have an impact on the emergence of the Shared Understanding. Due to the diversity of the development and requirement engineering approaches, we cannot claim that the results are representative for all development projects. Further, the team and stakeholders involved with their different backgrounds could have had an effect on the emergence of mutual and Shared Understanding. This study is a first step to analyse the emergence of mutual and Shared Understanding. To strengthen the results, other development teams with stakeholders from various disciplines should be analysed.

5.7 Conclusion

In this paper we analysed the emergence of mutual and Shared Understanding in the written communication of a multidisciplinary team that developed a mobile application. The team used application scenarios and an EasyWinWin requirement negotiation workshop to reveal and overcome a lack of understanding. We showed that the workshop helped to identify most conflicting goals of the stakeholders, but differences in the mental model were mostly identified in other stages of the process. Further, consolidation and elaboration questions belonging to mutual understanding were equally distributed in the process. Hence, we could not observe an effect by the requirement negotiation workshop. Even when artifacts were already agreed upon, the development team explored lack of mutual understanding to underlying concepts or relationships. If a Shared Understanding in the development team is important, there should be additional approaches used in requirement engineering activities.

This paper has several implications for research. We used a classification for mutual and Shared Understanding based on the process of conceptual change. This approach can differentiate the success of clarification techniques based on different types of understanding and can be used to get a deeper understanding of project communication. The results show that in our case study the requirements negotiation workshop worked well for most things but not for the crucial issue of different mental models. This indicates, on the one hand, the suitability of this requirements negotiation technique, but, on the other hand, calls for other techniques to build shared mental models. Future work should examine whether these observations can also be done in other settings.

In practice requirements, analysts should be aware that a lack of understanding can have different sources and that RE techniques are more or less suited to address the different types of mutual and Shared Understanding. If an agreement by stakeholders shall be reached, requirement analysts should spend effort to achieve a mutual understanding of the requirements and a shared mental model of the planned system before other kinds of conflicts are elaborated upon.

To foster mutual and Shared Understanding in interdisciplinary projects, we call for future research to analyse extent and forms of (lacking) mutual understanding in other development projects consisting of stakeholders from various backgrounds and using various development approaches. Further, we call for research that explores ways to systematically build upon this understanding.

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6 Why Shared Understanding Matters - Engineering a Collaboration Process for Shared Understanding to Improve Collaboration Effectiveness in Heterogeneous Teams

Eva Alice Christiane Bittner, Jan Marco Leimeister

Abstract: Solving complex problems often requires experience and perspectives of various, often heterogeneous experts. Shared Understanding of the task is an important determinant for the performance of collaborative groups (Mathieu et al. 2000; Langan-Fox et al. 2004). Surprisingly little attention has been paid to the systematic development of processes that lead to a Shared Understanding within heterogeneous groups. To address this challenge, we provide a systematic, reusable process to support groups to converge towards a Shared Understanding of a task to be then able to collaborate more effectively and efficiently. To achieve the proposed goal, we develop a collaboration process grounded in theory based design guidelines, including activities for individual (1) and collaborative construction of meaning (2) as well as constructive conflict resolution (3). We ground our work in group cognition research and apply a Collaboration Engineering approach (de Vreede et al. 2009). We test the process design in a computer-aided requirements elicitation workshop with experts from different professional backgrounds. We identify strengths and limitations of the process design to enable the development of thinkLets (reusable design patterns for Collaboration Engineering) for Shared Understanding in future research.

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6.1 Introduction

In knowledge economies, organizational work has become increasingly complex and requires more and more diverse expertise. Research on group work has shown that collaboration is critical for organizational productivity, as many tasks exceed the cognitive capabilities of any individual, also due to their complexity (Langan-Fox et al. 2004). Heterogeneous groups have been shown to outperform individuals in complex tasks, where a single person lacks the knowledge, skills and experience to solve it (Canon-Bowers et al. 2000; Wegge et al. 2008). Diverse groups with people from various backgrounds, with different experience and areas of expertise can provide substantial potential, if complementary skills and knowledge can be integrated successfully. While the members involved in the group usually do not have to be experts in all fields tackled by the project, "they have to be able to integrate their knowledge bases in a sensible manner" (Kleinsmann et al. 2010).

What we refer to as "Shared Understanding" of the task is both an important determinant for performance as well as a challenge in heterogeneous groups. Group members might be using the same words for different concepts or different words for the same concepts without noticing (de Vreede et al. 2009). They might be unaware of unshared individual knowledge which could be crucial for completing the task successfully. This can lead to substantial losses in efficiency in collaboration processes and suboptimal outcomes (Valkenburg and Dorst 1998; Mohammed and Dumville 2001; Darch et al. 2009). We aim to address this challenge by providing a structured collaboration process design based on theory grounded design guidelines that can be used to support heterogeneous groups to develop a Shared Understanding of an initially ill-defined task. With this paper we contribute to making the construction of Shared Understanding in heterogeneous groups more predictable and manageable. This is achieved by an overview of determinants of Shared Understanding, theory based design guidelines to ground systematic design efforts and a collaboration process that should lead to collaboration process design patterns for Shared Understanding.

6.2 Related Work

6.2.1 Shared Understanding

Confusion exists in literature, on the definition of Shared Understanding, it`s antecedents and effects and how Shared Understanding can be operationalized and measured. Sharedness encompasses various aspects, e.g. "similarity, agreement, convergence, compatibility, commonality, consensus, consistency, and overlap" (Mohammed et al. 2010). Two differing interpretations of "shared" can be found, namely shared as the joint possession of some resource versus the division of a resource between multiple recipients (Smart et al. 2009). While the latter refers e.g. to the distribution of tasks or knowledge among different people, the former covers the phenomenon we see in Shared Understanding. Groups, who are engaged in collaborative work need to have some knowledge and understanding in common, which functions as a joint reference base, in order to work productively. Thus, we focus the definition of "shared" for our purpose as some resource being possessed jointly by several people. A definition of Shared Understanding should reflect this view.

"Understanding is an ability to exploit bodies of causal knowledge (i. e. knowledge about the antecedents and consequents of particular phenomena) for the purpose of accomplishing cognitive and behavioral goals." (Smart et al. 2009). This definition of understanding highlights the importance of both knowledge as facts, and the structure of this knowledge. Causal knowledge is necessary for directed action towards the group goal. Seeing understanding as an ability, or "meaning in use" strengthens the viewpoint that understanding is more than knowledge, but involves reasoned action (Cannon-Bowers and Salas 2001; Mohammed et al. 2010). Whereas knowledge refers more to understanding of a current reality, evaluative beliefs target expectations about an expected or aspired future state, which we consider especially important for collaborative tasks, where the goal or product is not pre-specified in detail. Thus, understanding is not static, but a dynamic state.

Combining the thoughts on sharedness and understanding discussed above, Shared Understanding is "the ability of multiple agents to coordinate their behaviors with respect to each other in order to support the realization of common goals or objectives" (Smart et al. 2009). Based on the concept of joint possession of resources, this ability is based on "the overlap of understanding and concepts among group members" (Mulder and Swaak 2002). "Shared Understanding refers to mutual knowledge, mutual beliefs, and mutual assumptions" (Mulder and Swaak 2002).

Thus, we define Shared Understanding as an ability to coordinate behaviors towards common goals or objectives ("meaning in use" or action perspective) of multiple agents within a group (group level) based on mutual knowledge, beliefs and assumptions (content & structure) on the task, the group, the process or the tools and technologies used (scope/object perspective) which may change through the course of the group work process due to various influence factors and impacts group work processes and outcomes.

The popular construct of shared/team mental models, although it is differentiated from Shared Understanding by some authors due to its stronger focus on command and control teams with highly structured tasks (Mohammed and Dumville 2001) and its lack of consideration of evaluative beliefs (Mohammed and Dumville 2001; Langan-Fox et al. 2004), is closely related to Shared Understanding (Hsieh 2006). Therefore, we included team mental models research into our overview of related work, as long as it fits the definition of Shared Understanding described above.

6.2.2 Determinants and Effects of Shared Understanding

Positive effects of Shared Understanding in groups are discussed in prior work e.g. on performance (quality and quantity of group products) (Mathieu et al. 2000; Langan-Fox et al. 2004) group member satisfaction (Langan-Fox et al. 2004), co-ordination (Hsieh 2006), reduction of iterative loops and re-work (Kleinsmann et al. 2010), innovation (Kleinsmann and Valkenburg 2008) or team morale (Darch et al. 2009). Kleinsmann and Valkenburg (2008) also identify antecedents on an actor, project and company level, which are expected to influence the construction of Shared Understanding in groups. Langan-Fox et al. (Langan-Fox et al. 2004) distinguish between individual differences and environmental factors as determinants. Among the factors related to the individual and the group are e.g. individual personality and skills, team familiarity, authority, and diversity (Pascual 1999; Kleinsmann and Valkenburg 2008). Environmental factors such as physical proximity, incentives, communication support or organizational culture have also been discussed (Langan-Fox et al. 2004; Deshpande et al. 2005; Hsieh 2006; Kleinsmann and Valkenburg 2008). Furthermore, determinants concerning the collaboration process have been analysed (Kleinsmann and Valkenburg 2008) such as reasoning and communication, visualized beliefs and evidences, separation of individual and shared activity spaces, and training (Mohammed and Dumville 2001; Deshpande et al. 2005; Darch et al. 2009; Du et al. 2010). For the purpose of this paper, process variables are of special interest, as they provide reference points for design choices. If techniques and processes can be applied that support the creation of Shared Understanding in heterogeneous groups, those groups are expected to gain efficiency in their work and produce better results.

Mohammed et al. note, that "in order for a team to achieve a shared, organized understanding of knowledge about key elements in the relevant environment, changes in the knowledge and/or behavior of team members will most likely occur. Therefore, group learning plays a significant role in the development, modification, and reinforcement of mental models" (Mohammed and Dumville 2001). Some recent research has started to examine the relationship between interaction and group learning/Shared Understanding (see e.g. (Fischer and Mandl 2005; Jeong and Chi 2007). However, a lack of knowledge can be identified concerning the specific patterns that lead to the construction of Shared Understanding (van den Bossche et al. 2011). Van den Bossche et al. have addressed this gap by developing and testing a model of the team learning behaviors leading to the construction of Shared Understanding (figure 1) (van den Bossche et al. 2011). This model constitutes the theoretical basis for our design guidelines and design decisions. It will be described in detail in section four.

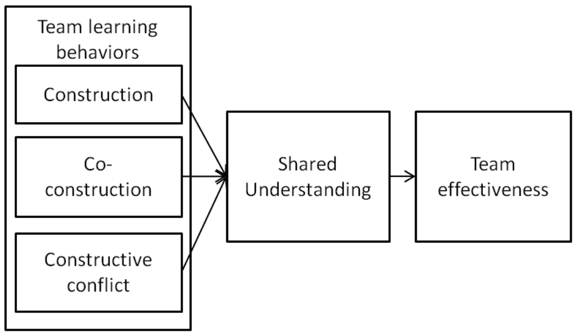

Figure 1. conceptual model of team learning behaviors
Source: Van den Bossche, Gijselaers et al. (2011)

We focus on the antecedents in this model for the purpose of an initial design, as they are process variables and well specified. For later design iterations, other or additional antecedents presented in the overview might be considered.

6.3 Method

For developing the collaboration process, we followed the Collaboration Engineering design approach (Kolfschoten and de Vreede 2007). Collaboration Engineering addresses the challenge of designing and deploying collaborative work practices for high value recurring tasks (de Vreede et al. 2009). As the construction of a Shared Understanding of ill-defined tasks is crucial for many collaborative tasks, high-value and recurring, it falls into the scope of Collaboration Engineering.

Much prior Collaboration Engineering research focuses on tasks for generation, evaluation etc, but little documented reusable procedures were found on how to support the "clarify" pattern of collaboration (see the FastFocus thinkLet in Briggs and de Vreede (2009) for thinkLet aiming at clarification). Following Briggs (2006), to clarify means to "Move from having less to having more Shared Understanding of concepts and of the words and phrases used to express them" (Briggs et al. 2006) and thus reflects processes for the construction of Shared Understanding. Although the core pattern involved in the construction of Shared Understanding is "clarify", we are using a broader perspective on the process of building Shared Understanding than Briggs' definition reflects. Therefore, other patterns are likely to be involved in this process.

Briggs (2006) argues, that grounding collaboration process design in good theory can enable unexpected success, as it can lead to non-intuitive design choices. Causal relationships described in theory provide designers of collaboration processes with hints for options they would not have considered without the theory.

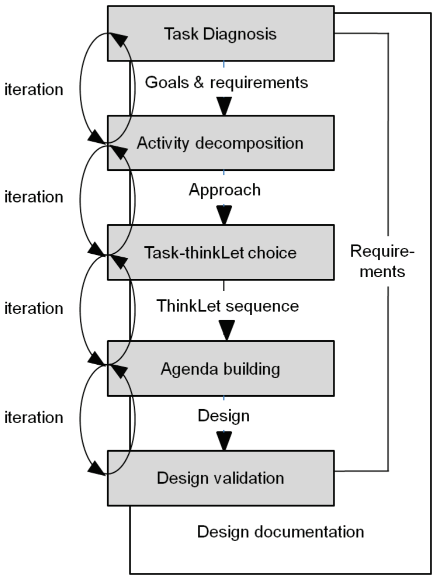

Figure 2. Collaboration Process Design Approach
Source: Kolfschoten and de Vreede (2007)

Good theory for design is hereby characterized by a model of causal effects, where the phenomenon of interest is the effect (in our case Shared Understanding), which should be evoked by the means of a design (in our case the collaboration process). The design of collaboration systems used to be more of an art than science for many years and successes or failures where hard to explain and repeat as they were based on intuition and seat-of-the-pants reasoning (Briggs 2006). It is the aim of Collaboration Engineering to develop predictable, reusable designs that support a class of recurring work practices. Thus, limited predictability and transferability of unsystematic approaches hinders the contribution of Collaboration Engineering work. Grounding collaboration system design in rigorous theory can help overcome those pitfalls, systematically improve collaboration research over time and point to solutions that are not intuitive (Briggs 2006).

Thus, we used theory based design to ground the design choices for the process on prior theoretical knowledge. Starting with van den Bossches model on learning mechanisms' influence on Shared Understanding, we deducted general design guidelines for each of the antecedents on which we based our design choices. The design guidelines are used to split the task (constructing Shared Understanding) into a manageable and repeatable sequence of activities. We validated the process design in a pilot requirements negotiation workshop with experts from different professional backgrounds.

6.4 Theoretical Model: Team learning behaviors for the construction of Shared Understanding

Grounding on group cognition research from learning sciences and organizational sciences, van den Bossche, Gijselaers et al. (2011) examined three kinds of team learning behaviors. They tested the effect of construction, co-construction and constructive conflict on the development of shared mental models. Furthermore, they measured, how shared mental models mediate the effect of team learning behaviors on team performance.

Construction of meaning is referred to as "when one of the team members inserts meaning by describing the problem situation and how to deal with it, hereby tuning in to fellow team-members. These fellow team-members are actively listening and trying to grasp the given explanation by using this understanding to give meaning to the situation at hand" (Webb and Palincsar 1996).

Collaborative construction (co-construction) is “a mutual process of building meaning by refining, building on, or modifying the original offer in some way” (Baker 1994). Construction and co-construction lead to mutual understanding. However, mutual understanding does not yet mean that group members share one perspective or are able to act in a coordinated manner. As our definition of Shared Understanding involves a “meaning in use” aspect, mutual agreement on one perspective is furthermore necessary to achieve Shared Understanding.

Mutual agreement is achieved through constructive conflict, “dealing with differences in interpretation between team members by arguments and clarifications” (van den Bossche et al. 2011). Following van den Bossche’s model, collaborative groups should express, share and listen to their individual understanding (construction), discuss and clarify them to reach mutual understanding (co-construction) as well as controversly negotiate an agreement on a mutually shared perspective (constructive conflict).

Determinant	Item	Design Guideline
Construction	Team members are listening carefully to each other	G1: Express individual understandings first
		G2: Encourage members to try to understand each individual perspective
	If something is unclear, we ask each other questions	G3: Ask questions for clarification
Co-construction	Information from team members is complemented with information from other team members	G4: Collect individual descriptions in one shared place
	Team members elaborate on each other’s information and ideas	G5: Evaluate understanding and consistency with own perspective
	Team members draw conclusions from the ideas that are discussed in the team	G6: Proceed on differences between understandings
Constructive conflict	In this team, I share all relevant information and ideas I have	G7: Encourage sharing of divergent views (parallel and anonymous)
	This team tends to handle differences of opinions by addressing them directly	G8: Address differences in discussion
	Comments on ideas are acted upon	G9: Process every conflicting aspect
	Opinions and ideas of team members are verified by asking each other critical questions	G10: Allow clarification questions and conflict negotiation

Table 1. Theory based design guidelines
Source: Own representation

Van den Bossche, Gijselaers et al. (2011) found that those team learning behaviors positively influence the construction of shared mental models among students working on a business simulation game. The three team learning mechanisms are operationalized by 9 items, which are displayed in table 1. As construction, co-

construction and constructive conflict should be evoked by the process design, we derived general design guidelines (G1-10) from each item. The process design should reflect those aspects.

6.5 Design

The goal of the collaboration process to be designed is to build a Shared Understanding of an ill-defined group task in heterogeneous work groups at the beginning of group work. In order to design for that goal, we want to evoke the three learning mechanisms construction, co-construction and constructive conflict within the collaboration process. To systematically derive design choices, we first deducted 10 general design guidelines from the operationalized constructs, which are displayed in table 1.

We splitted the collaboration process into seven activities to reflect the different learning mechanisms (displayed as a Facilitation Process Model (De Vreede and Briggs 2005) in figure 3). The first three activities mainly address construction of meaning. At the beginning of the collaborative process, group members need to make sense of the task individually (G1), as it is new to them (A1). In order to allow group members to look into each others' perspectives and develop mutual understanding, the individual conceptions need to be explicitly communicated (A2). We decided for written documentation over spoken words. Written documentation also allows the group to work in parallel (G7) on their descriptions (especially in computer-aided settings) and to return to a text if something is unclear.

The product of A2 is a description of every participant, which reflects his perception of the group task. Those documents are collected in the group support system and serve as an input for the following construction and co-construction efforts, which are carried out mainly in activities three to five.

A3 encompasses dedicated time for reading ("listening" – G2) and clarification of the individual descriptions by questioning (G2, G3). As all participants are encouraged to evaluate the clarity of each description, they are motivated to read each text carefully and reflect on their understanding. Thus, the aspired product of activity three is an understanding of all individual descriptions by all participants. It has to be noted, that those understandings might still differ and mutual agreement has not been reached yet.

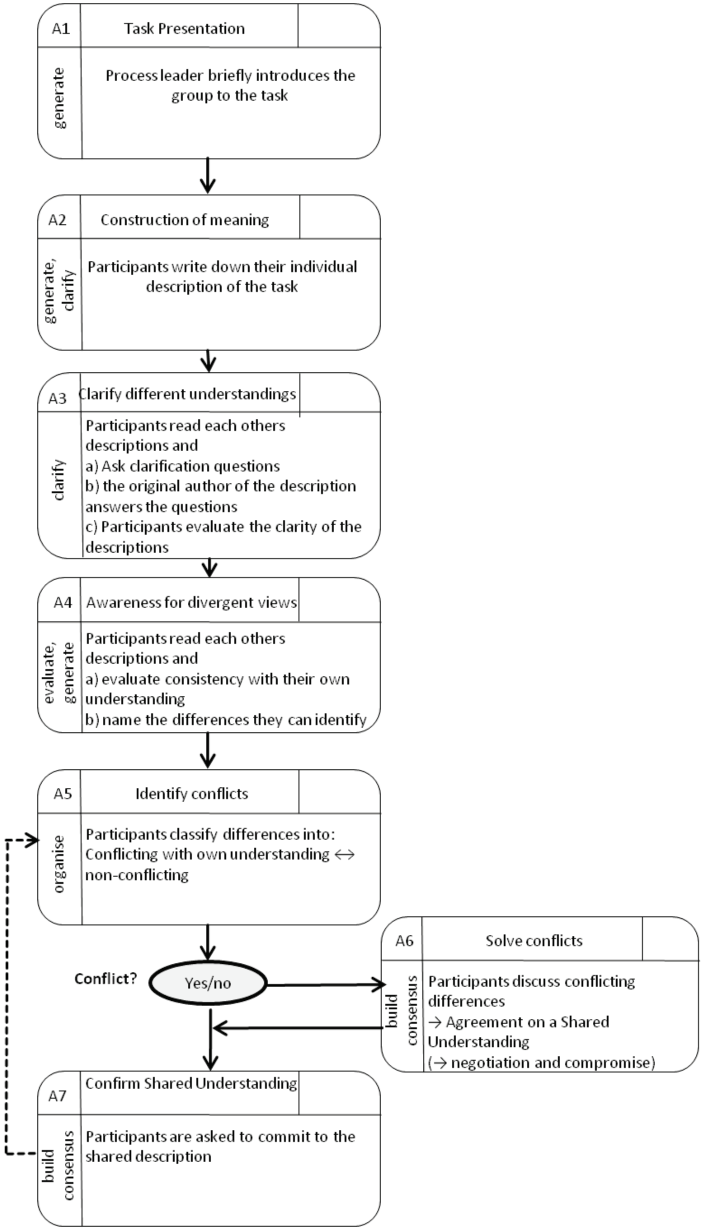

Figure 3. Collaboration process design for Shared Understanding

Source: Own representation

Divergence is identified in A4 as part of the co-construction phase (G5), where participants evaluate the consistency of each description with their own view and name the differences they observe. This activity is a prerequisite for building a connection between the separate descriptions and converging on one shared description. The differences are further processed in activity five (A5), where they are categorized into differences that provoke a conflict between the different views and those that can be integrate into a shared perspective without a need to decide for one alternative (G6). The conflicts are solved in a discussion in activity six (A6) (G8, G10). If a consensus can be reached, it will be included in the shared description, in addition to all non-conflicting aspects. If the participants don`t agree initially, a compromise will be negotiated, until a consistent description, reflecting the understanding of the group, results (G9). The process concludes with another voting activity (A7), asking for the agreement of participants to the shared description. The evaluation results are discussed. If participants still report a lack of Shared Understanding on the tasks, an iterative loop towards activity five (A5) can be used to solve remaining conflicts (G8, G9). The process has reached its end, as soon as all participants signal commitment to the shared description.

6.6 Validation

Collaboration process designs need to be validated before they should be implemented in practice, preferably combining different validation techniques (Kolfschoten and De Vreede 2009). Therefore, we first conducted a focus group with three experts on group work and Collaboration Engineering. Different design alternatives were discussed concerning their expected outcomes, critical points in the process and possible technology to implement them. The main changes after this discussion were some minor adaptions to the wording of the instructions to make them clearer and switching activitites A3 and A4 in the process. The experts agreed, that clarification of the individual understandings should be done before identification of divergent views to avoid misunderstanding and inefficient discussions in the "awareness for divergent views" activity. The process displayed in figure 3 reflects the design after the focus group meeting.

In addition to discussing the design with other researchers in Collaboration Engineering (expert validation (Kolfschoten and De Vreede 2009)), we conducted a pilot workshop with 11 professionals from different academic and non-academic backgrounds. The workshop was organized by the authors and observed by a collaboration engineer, instructed to look for weaknesses of the design and unexpected occurrences. The workshop moderator and the observer took field notes, which were discussed afterwards. Comments of the participants, which were related to the collaboration process (e.g. if they found it hard to understand an instruction or mentioned problems with the tool) were documented and interpreted qualitatively by the authors and the observer. Furthermore, noticeable events in the interaction of the participants were treated alike. This pilot implementation should serve as a proof of concept for the collaboration process design and reveal problems and optimization potentials prior to a larger experimental evaluation.

The task for the requirements elicitation workshop was to identify requirements for a digital game based learning application. The game should allow inhabitants of a certain neighbourhood to learn about the history and culture of their surrounding by being navigated between interesting locations in their city and solving little puzzles at those locations. Developers, users, legal experts and project sponsors were invited to contribute their requirements in a 4-hour workshop, which was documented on video. Some of the participants knew the project beforehand; others were introduced to the topic at the beginning of the workshop. Group support software Think Tank 3.0 by Group Systems was used to implement the process (note: the general process has been designed independent of technology). After a short introduction, the first one and a half hours of the workshop was used to build a Shared Understanding of the workshop task, based on the prior modelled process. Table 2 shows a translated version of the instructions and questions given to the participants.

Participants were asked to write a description of what they think the game they would have to specify is about, how it works and what its purpose should be (A1). Activities two to five (A2-A5) were conducted completely within the group support system in a same place same time session. This way, everyone could take the time to read each others' description thoroughly and all written communication was documented in the group support system. Activities six and seven (A6, A7) were done in a moderated group discussion.

	Guiding Questions/Instructions
A2	Please describe thoroughly the result of this workshop. What do you imagine [the game] to look like?
A3	a) Please read through all descriptions of the other participants and leave a comment on each aspect you do not understand and would like to get explained.
	b) Briefly answer the questions that refer to your description of the game to clarify the point .
	c) Please indicate on a five-point-scale for each of the descriptions (including the comments on the description), how clear it is to you (1=very unclear, 5=very clear).
A4	a) Please indicate on a five-point-scale for each of the descriptions, how much it reflects your own view on the game (1=I don`t agree at all with the description, 5= I agree completely).
	b) In which aspects do the descriptions differ? Please write down any differences concerning the game that you notice.
A5	Please sort the differences you indentified into conflicting and non-conflicting ones. Conflicting differences are those which endanger the success of your group work and which need to be resolved to come to a solution. Non-conflicting differences are those, where both perspectives can be integrated in the solution.
A6	How should we proceed with the conflicting differences? Which shared perspective can we agree on to include in a common description?
A7	Please indicate on a five-point-scale your perception on how much Shared Understanding on the result of this workshop is present in the group.

Table 2: Guiding questions for each activity
Source: Own representation

At the end of the Shared Understanding process, participants were asked to fill out a questionnaire on the learning mechanisms and their perceived team effectiveness. This questionnaire was mainly used to examine whether participants face any issues to understand the translated items. However, it can be noted that all constructs were rated above 4,7 on a 7-point Likert Scale on average. Team effectiveness received an average rating of 5,3, which indicates that participants were relatively satisfied with the group work. The team learning behavior with the highest average rating was construction (5,9), followed by co-construction (5,8) and constructive conflict (4,7). The lower value of constructive conflict might be an indication that constructive conflict might rely on the other two behaviors as a basis and might be more difficult to achieve.

Further investigations should examine this observation. As there was no control group in this initial workshop, results could not be compared. Afterwards, the workshop continued with requirements elicitation activities.

6.7 Discussion

The validation disclosed several potentials for improvement for the process design as well as limitations of the technology in use. First, we noted that participants had problems articulating a thorough description of their understanding of the task in a continuous text in activity A2. Although guiding questions were given that asked for a comprehensive description of the game idea and process, some participants tended to enter unrelated creative ideas for game features or requirements. As those modifications came mostly from participants relatively unfamiliar with the game, we suggest adaptions of the process: A narrower pre-set structure of the description should be given to reduce cognitive load, e.g. "What is the goal of [the game]? How can the game logic be described? Which phases does a player go through when playing [the game]?"

Other representations than plain text should also be tested (e.g. mindmaps or other graphical representations of the content) to make it easier for participants to explicate and structure their knowledge. The suggestion of Saad et al. (Saad and Maher 1996), who propose flexibility in the design of collaboration processes to allow participants to chose and combine different media to express their understanding, using visual as well as semantic representations, should be examined for its applicability for the process discussed here.

Furthermore, people should be given one separate space to write and edit their own description before submitting it in activity A2. This adaption would be consistent with Deshpande et al. (2005), who argue that a separation of personal and shared spaces are advantageous to create Shared Understanding. Submitting each text part immediately (although it could still be edited) shifted the focus away from deep consideration of one's individual description.

Another issue that could be observed was that participants mentioned problems to keep relevant information in mind during activity four (A4). The high cognitive load in activity four, might partially be caused by the group support system, as it did not allow participants to read descriptions, evaluate and take notes on differences in parallel. Thus, group members had to keep the difference in mind, which they spotted while reading the texts until they could write them down after the evaluation step. Therefore, in a next instantiation of the process design, it is recommended to implement all actions included in activity four (A4) in a way that participants could switch between actions as they process each description. Thus, while doing the formal evaluation, they should be able to write down each difference they come across.

Difficulties in handling the textual descriptions were further increased by the technical limitations of the tool. The group support system ThinkTank, although very powerful for large lists of short ideas, shows problems when larger text blocks should be displayed and processed. Participants noted that it was hard and non intuitive to read through the texts, as extra windows had to be opened manually to display whole descriptions. We suggest to use alternative tools, which are designed for text processing, for a thorough test of the process. As the collaboration process needs to be evaluated independently of technology, technology support should reflect and not hinder the process design.

6.8 Implications, limitations and further research

We developed a systematic, reusable process to support groups to converge on a Shared Understanding of a task to be able to collaborate effectively and efficiently. This process design contributes to Collaboration Engineering research by exploring design opportunities for a crucial process in group work, which still lacks systematic support. The main theoretical contribution of this paper lies in the application of van den Bossches (van den Bossche et al. 2011) causal model to solve a class of problems, namely to construct Shared Understanding in hetereogeneous groups through construction, co-construction and constructive conflict.

We derived theory based design guidelines and a process design which helps group work scholars to systematize their research on the construction of Shared Understanding. If tested in several settings, refined based on our suggestions and documented in a standardized thinkLet format, this process can contribute to Collaboration Engineering research. ThinkLets for building Shared Understanding should be developed based on that research to address the lack of reusable and tested procedures for the “clarify” pattern of collaboration.

This paper constitutes a first step in this effort. If the process evokes the causal effects as intended, practitioners can use it to construct a better Shared Understanding and increase team effectiveness in their collaborative work. Thus, design guidelines and the process design described in this paper contributes to more systematic design for Shared Understanding in heterogeneous groups.

A limitation is that so far it could not be proven, if the process design is able to evoke the effects it intends to. The validation we did served as a proof of concept and revealed valuable improvement potentials for the process, but the effects on Shared Understanding and team effectiveness need to be tested in experimental settings with treatment groups following the process and control groups with unstructured group work in future research. Different instances of the process will implemented to test the claim of solving a whole class of problems.

Furthermore, we identified some limitations due to the technology support, which was not able to support all process design choices in an optimal way. Alternative implementations should consider those issues. As shown in the review of related work, Shared Understanding is a complex construct with various impact factors and effects. Thus, any collaboration process design can only consider selected aspects of Shared Understanding (in this case, Shared Understanding of the task) and alternative explanations for changes in Shared Understanding are hard to control for in complex collaboration processes. Further consideration of this complexity is required as well as research on suitable measurement instruments to analyze Shared Understanding in field settings.

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7 Engineering for Shared Understanding in Heterogeneous Work Groups - An Action Research study at a German Automotive Company

Eva Alice Christiane Bittner, Axel Hoffmann, Jan Marco Leimeister

Abstract: Heterogeneity in work groups creates challenges to build a Shared Understanding among diverse group members and to integrate knowledge of different actors successfully. In an action research study with experience diverse tool and dye-makers at a German car manufacturing company, we developed a collaboration process design to systematically support heterogeneous groups in building a Shared Understanding of the sequence of activities in complex work processes. Participants showed the intended team learning behaviors and an increase in Shared Understanding.

Keywords: Collaboration Engineering, Shared Understanding, Knowledge Integration, Heterogeneous Groups

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7.1 Introduction

7.1.1 Motivation

Research on group work has shown that collaboration is critical for organizational productivity, as many tasks exceed the cognitive capabilities of any individual, due to their complexity (Fischer 2000; Langan-Fox et al. 2004). It also shows that diverse groups can perform better on complex tasks than homogeneous groups (Canon-Bowers et al. 2000; Wegge et al. 2008). The existence of heterogeneous perspectives or "symmetry of ignorance" in groups has the potential to provide opportunities for creativity in solving ill-defined, wicked problems (Fischer 2000).

Heterogeneity in teams often leads to communication breakdowns and project failure. While group members usually do not have to be experts in all fields tackled by a complex project, "they have to be able to integrate their knowledge bases in a sensible manner" (Kleinsmann et al. 2010). Otherwise, they might be unaware of unshared individual knowledge which could be crucial for completing the task successfully. Building a Shared Understanding "is important because people frequently use the same label for different concepts, and use different labels for the same concepts. People on a team also frequently use labels and concepts that are unfamiliar to others on the team" (de Vreede et al. 2009). As no standard definition of Shared Understanding has evolved yet, we define Shared Understanding as an ability of multiple agents within a group to coordinate behaviors towards common goals or objectives based on mutual knowledge, beliefs and assumptions on the task, the group, the process or the tools and technologies used, which may change through the course of the group work process due to various influence factors and impacts group work processes and outcomes (Bittner and Leimeister 2013). The challenge is that diverse work groups may lack a Shared Understanding of the task, the characteristics of the group, the products to be developed or the collaboration process due to their different background and experience.

If techniques and processes can be applied that support the creation of Shared Understanding in diverse groups, those groups are expected to gain efficiency in their work and produce better results. This paper examines the challenge of knowledge integration in heterogeneous work groups in a real world setting at a German car manufacturing company. We chose and action research approach to develop a solution for the specific problem situation, while simultaneously investigating the phenomenon of Shared Understanding and knowledge integration in heterogeneous teams. The practical goal of this project is to design a reusable collaboration process by which experienced and inexperienced group members should increase their individual understanding by adopting knowledge from each other and agree on a Shared Understanding of a specific work process. The research goal is to exploratively generate new insights on the mechanisms leading to Shared Understanding in heterogeneous group work. While a basic version of the process logic itself was proposed earlier (Bittner and Leimeister 2013), we address the following questions here: How do the designed collaborative work practices evoke group learning mechanisms? How are these mechanisms related to changes in Shared Understanding in the heterogeneous groups?

The paper is organized as follows: First we point out our underlying understanding of Shared Understanding. In section two, the research setting and our action research approach are outlined. Sections three to seven follow the action research logic and describe, how we (3) diagnose, (4) plan, (5) intervene, (6) evaluate and (7) specify the learning in the action research study. The paper closes with a consideration of implications, limitations and outlook on future research.

7.1.2 Shared Understanding

Two differing interpretations of “shared” can be found in literature, the division of a resource between multiple recipients versus the joint possession of some resource (Smart et al. 2009). While the former refers to the distribution of tasks or knowledge among different actors, the latter covers the phenomenon we see in Shared Understanding. Groups, who are engaged in collaborative work need to have a joint reference base of knowledge and understanding in common in order to work productively. Thus, we focus the definition of “shared” for our purpose as some resource being possessed jointly by several people, based on “the overlap of understanding and concepts among group members” (Mulder and Swaak 2002). “Understanding is an ability to exploit bodies of causal knowledge (i. e. knowledge about the antecedents and consequents of particular phenomena) for the purpose of accomplishing cognitive and behavioral goals” (Smart et al. 2009). This definition of understanding highlights the importance of both knowledge as facts, and the structure of this knowledge. Causal knowledge is necessary for directed action towards the group goal. Seeing understanding as an ability, or “meaning in use” strengthens the viewpoint that understanding is more than knowledge, but involves reasoned action (Cannon-Bowers and Salas 2001; Mohammed et al. 2010). “Shared Understanding refers to mutual knowledge, mutual beliefs, and mutual assumptions" (Mulder and Swaak 2002) in order to reflect subjective aspects of understanding and future oriented assumptions in addition to objective factual knowledge. We make this inclusion, as especially for complex tasks, there might not be one single right understanding. The construct of shared/team mental models is closely related to Shared Understanding (Hsieh 2006) and is thus included in our work wherever useful, especially for the assessment of documents generated throughout the process. Although it is differentiated from Shared Understanding by some authors due to its stronger focus on command and control teams with highly structured tasks (Mohammed and Dumville 2001) and its lack of consideration of evaluative beliefs (Mohammed and Dumville 2001; Langan-Fox et al. 2004). In the study at hand, we focus mainly on Shared Understanding concerning the group task, in particular the work process the group should document.

7.2 Methodology

7.2.1 Research Setting

The authors were asked to improve collaboration of experienced and inexperienced tool and dye makers and increase the mutual knowledge transfer to ensure the retention of tacit knowledge within the organization independent of individual people. The organization was a big German car manufacturer. The goal was to build training blocks that helps inexperienced worker to execute complex work tasks.

As many other organizations, this company faces an increasing challenge to enable its members to integrate diverse knowledge. Longtime employees with great experience and deep understanding of the company's processes are confronted with unfamiliar rapid technological change in their work environment. When approaching retirement age, the organization is endangered by losing the skills and tacit knowledge of those people, if no appropriate means are in place, which support the transfer of knowledge to new employees. New employees on the other hand bring recent technological education and an unbiased view on established work processes, but may lack the specific skills and expertise in highly complex fields. Young employees with recent educational knowledge and older, more experienced employees should be able to learn from each other to prevent critical knowledge from disappearing. Demographic change enforces this challenge, as a big proportion of experts are reaching retirement age and only a small number of young technicians are qualified to fill their positions. Both experienced and inexperienced group members need to understand each other's perspective and converge on a Shared Understanding in order to work together effectively.

Heterogeneity of group members becomes manifest in this setting in different dimensions, such as age, gender, formal education, work experience, duration of association with the company etc. In particular, we paid attention to the equal staffing of each group concerning members with much vs. little experience with the specific work task the group should document. 36 workers participated in the project, 5 females and 31 males. Experienced participants were on average 42.83 years old, inexperienced 23.06 years, with the youngest participant being 19 years old and the oldest 57. Total job experience of the participants reached from as low as 5 weeks up to 42 years.

	Non-Experienced	Experienced	Overall
Gender			
Female	4	1	5
Male	14	17	32
Total	18	18	36
Age			
Min	19	23	19
Mean	23.06	42.83	32.94
Max	30	57	57
Job Experience			
Min	0.1	1	0,1
Mean	5.3	23.25	14.53
Max	14	42	42

Table 1. Demographics of heterogeneous participants
Source: Own representation

As heterogeneity is given in the project and Shared Understanding can be expected to be critical for the solution to the practical problem situation, it is well qualified as an action research field to explore the general phenomenon described in the introduction.

7.2.2 Action Research Approach

Shared Understanding is a complex phenomenon in real world settings and no sufficient body of theory is available to explain the mechanisms leading to Shared Understanding, which could be used to guide design efforts. Therefore we chose an exploratory research design. Exploratory research allows the researcher to gather unexpected observations, examine the phenomenon in a holistic way and react flexibly to new insights. To allow for a holistic view and compensate for the weakness of individual data collection methods, a combination of several data collection methods has been selected. Action research has been chosen as research framework for the study.

Action research is a research approach from social sciences, where the researcher gets actively involved in the intervention and interacts with the members of the focal organization. On the one hand it aims at changing the social system and solving a concrete real world problem. On the other hand, new insights on the system and the phenomenon of interest should be gathered (Baskerville 1999).

In a systematic cyclical process, the state of specific field situations should be understood and changed. Five phases are passed in an iterative, cyclical way, namely diagnosis, action planning, action taking, evaluation and specifying learning. In this paper, we follow the extended action research model by McKay and Marshall (2001), who make a distinction between problem solving cycle and a research cycle. The two cycle approach has been chosen to address the dual goal of action research and counteract the critics of lacking research rigor of action research. The research cycle aims at exploring the real world phenomenon of interest to gain insights on the theoretical research framework. It leads to answering the research questions specified in section one and helps building a theory or elements of new theory. The problem solving cycle aims at improving the specific real world problem situation by using a problem solving method to execute an intervention. In the study that underlies this paper, the problem situation exists in the challenge of supporting experience diverse work groups at a car manufacturing company to integrate and transfer their heterogeneous knowledge. The problem solving cycle results in a collaboration process design as the artifact that has been developed to change the real world situation. If the problem situation is related to the phenomenon of interest and is suitable to explore the phenomenon of interest, both cycles can benefit from each other. The dual approach is consistent with Briggs' (2006) claim to separate theory building research from the specific artifact/technological instantiation by defining separate research and engineering questions. The action research design and findings are described in sections three to seven. The piloting project with six teams allowed executing six iterative cycles.

7.3 Diagnosis

In the diagnosis phase, the problem situation is identified and the phenomenon of interest is specified.

7.3.1 Real World Problem Situation

From a problem solving perspective, the specific real world problem situation in the organization is diagnosed. In close interaction with the client organization the goals and general requirements for the piloting project are defined. From a practical point of view, this project aims at engineering a collaboration process design to improve knowledge integration and knowledge transfer concerning complex handcraft work processes within diverse work groups. In a series of three workshops, groups of six tool and dye makers should document a specific work process and develop learning material for new employees. The collaboration process needs to be standardized enough to be transferred to and executed by the organization at a later stage. In parallel to solving this specific problem situation, the project enables us to examine the more general problem of Shared Understanding in heterogeneous groups, as the groups are very diverse in their background, gender, age and work experience. While the practical solution includes further goals, e.g. producing the learning material as an artifact, Shared Understanding among the team members on the work process can be assumed as one central aim. Therefore, this pilot project seems suitable for exploring Shared Understanding from a research point of view.

7.3.2 Initial Research Framework

From a research perspective, we want to examine mechanisms leading to Shared Understanding in collaborative work. We are interested in analyzing how those mechanisms can be evoked by specifically designed collaborative practices. This research goal is based on the assumption that Shared Understanding is a dynamic state, which changes through the course of collaborative interaction due to certain mechanisms and that those mechanisms can be influenced to some extent by design choices (Bittner and Leimeister 2013). According to McKay and Marshall (2001) an initial research framework should guide the development of first design hypotheses. The collaborative practices we discuss in this paper are grounded on van den Bossches et al.'s (2011) model of construction, co-construction and constructive conflict as mechanisms leading to Shared Understanding. Grounding on group cognition research from learning sciences and organizational sciences, van den Bossche et al. (2011) examined three kinds of team learning behaviors. They tested the effect of construction, co-construction and constructive conflict on the development of shared mental models. Furthermore, they measured how shared mental models mediate the effect of team learning behaviors on team performance.

Construction of meaning is referred to as “when one of the team members inserts meaning by describing the problem situation and how to deal with it, hereby tuning in to fellow team-members. These fellow team-members are actively listening and trying to grasp the given explanation by using this understanding to give meaning to the situation at hand” (Webb and Palincsar 1996).

Collaborative construction (co-construction) is “a mutual process of building meaning by refining, building on, or modifying the original offer in some way” (Baker 1994). Construction and co-construction lead to mutual understanding. However, mutual understanding does not yet mean that group members share one perspective or are able to act in a coordinated manner. As our definition of Shared Understanding involves a “meaning in use” aspect, mutual agreement on one perspective is furthermore necessary to achieve Shared Understanding.

Mutual agreement is achieved through constructive conflict, “dealing with differences in interpretation between team members by arguments and clarifications” (van den Bossche et al. 2011). Following van den Bossche’s model, collaborative groups should express, share and listen to their individual understanding (construction), discuss and clarify them to reach mutual understanding (co-construction) as well as controversly negotiate an agreement on a mutually shared perspective (constructive conflict).

7.3.3 Collaboration Engineering as Problem Solving Method

In the diagnosis phase, Collaboration Engineering is chosen as the problem solving method, as it aims at developing reusable collaborative practices for high value recurring tasks that can be executed without the ongoing intervention of a professional facilitator (de Vreede et al. 2009). This matches the demand of the organization for a solution which can be transferred from the researchers who engineered the pilot process to the organization itself. The collaboration process design should be piloted, tested and documented for its future use by practitioners.

7.4 Action Planning

7.4.1 Intervention Planning to Improve the Problem Situation

In the action planning phase, the intervention to improve the problem situation is developed. We use the Collaboration Process Design Approach (Kolfschoten and De Vreede 2009) to implement the goal (improve knowledge integration and transfer in the group while documenting work processes collaboratively) in a collaboration process design. We split the collaboration process into a series of three one day workshops with homework activities in between the workshops. Only the first workshop is discussed in this paper, as these activities are dedicated to creating Shared Understanding of the sequence of activities required in the work process and we focus on examining Shared Understanding here.

The workshop is characterized by three main phases, (1) an individual description (draft) of the craftsmen’s work process, (2) integration of the individual drafts in pairs of two and finally (3) the integration of the pairwise drafts in one solution that all six group members commit to. This structure reflects the need for a shared representation of the sequence of activities in the work process at the end of the first workshop. The individual phase is based on the assumption, that an individual working space and individual reflection is critical, as members need to be aware of their own mental model. An individual representation should help by encouraging individual construction of knowledge, reflection and can serve as a boundary object and reminder of the aspects to discuss in the pairwise phase. A pairwise phase has been included between individual and group work to foster the exchange between experienced and inexperienced participants. While in a larger group experienced members could easily take over the discussion and less experienced or less extroverted people might resign from contributing to the group product, in pairs of one experienced and one inexperienced member, both perspectives are likely to be heard.

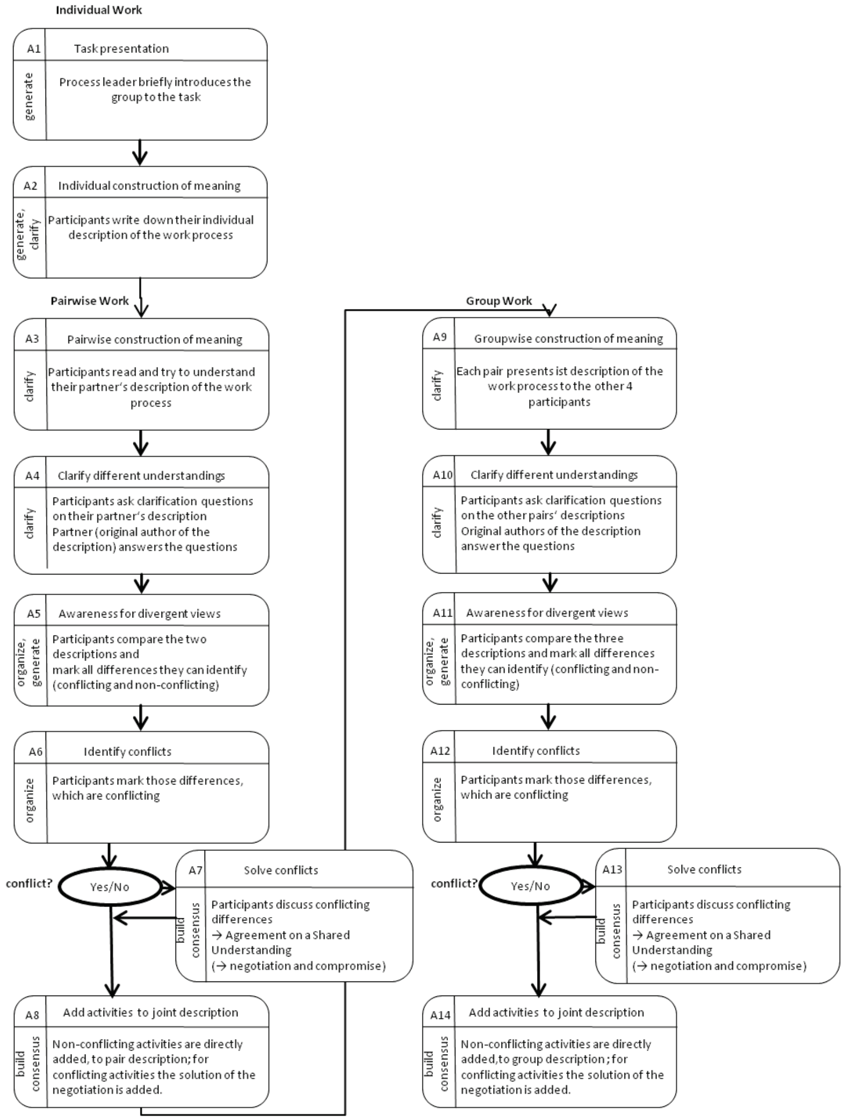

Figure 1. FPM of Collaboration Process Design for the Construction of Shared Understanding
Source: Own representation

Both collaborative phases (pairwise and group) are further divided into three activities each according to the three learning mechanisms proposed by van den

Bossche et al. (2011). First, the participants try to make sense of the documents for themselves by reading their partners or groups work process description. Second, clarification questions are collected and answered to foster the co-construction of meaning and the evolution of mutual understanding. However, mutual understanding is not sufficient for coordinated action, meaning the collaborative development of learning material based on a Shared Understanding of the work process. As the two (or three in the group) drafts may still differ or even contradict each other in certain aspects, a third activity aims at evoking constructive conflict. Participants are asked to identify and resolve differences as well as conflicts in a discussion, before integrating their drafts into one that all agree on. A detailed description, how the specific activities are grounded in the theoretical framework of the team learning behaviors can be found in (Bittner and Leimeister 2013). Figure 1 shows the collaboration process design in a facilitation process model (FPM) notation. In combination with a short introduction and a wrap-up, this process design is the basis for the first workshop day with six groups of six employees each from a car manufacturing company.

7.4.2 Choice of Data Collection Methods

For the research cycle, the data collection methods are selected in the action planning phase. In order to allow for a holistic exploration of the phenomenon of interest, a structured survey before and after the workshop is combined with field notes of the moderator and facilitator as well as a content analysis of the artifacts that evolve during the collaborative work. Those artifacts, the work process descriptions, are interpreted as individual, pairwise and group cognitive maps.

7.5 Action Taking

In the action taking phase, the planned intervention is executed in the field. The researcher interacts directly with the participants and actively gets involved in the changes introduced to the problem situation. For the problem solving cycle, this means that the artifact – in our case the collaboration process design – is pilot tested. Six pilot workshops are executed with groups of six tool and dye makers each. Every workshop lasted for seven hours with a lunch break and several smaller breaks. They took place in a university collaboration laboratory to release the participants from their daily routine and were moderated by one of the authors. Another Collaboration Engineering researcher facilitated and observed the workshop process. As the action research approach demands an iterative development of the solution, the full cycles where run through for every group and necessary adjustments were made to the process design after each cycle. Data for gaining new insights on the problem field as well as on Shared Understanding as the phenomenon of interest where collected throughout each cycle. We will present these results and insights in an aggregated manner in the following sections.

7.6 Evaluation

In the fourth phase of the action research cycle, it is evaluated whether the intervention has had the intended effects and whether those effects were able to improve the problem situation. In particular we examine if the participants showed the three group learning mechanisms construction, co-construction and constructive conflict in the course of the collaborative process, that the collaborative practices were meant to evoke. Furthermore, we analyze whether Shared Understanding increases throughout the process and how the mental model of the work process of the participants changes towards a joint representation. For the problem solving cycle, the evaluation provides information in how far the intervention reached the goals that were set for the project, e.g. concerning knowledge transfer, group cohesion or satisfaction of the participants. The practical evaluation provides indication for the adjustments to the design that are necessary in the next problem solving cycle as well as when the action research project can be closed. For the purpose of this paper, we focus on the evaluation for the research focus of the project. In addition to new knowledge on the research frame, insights on the phenomenon of interest are gathered. Every instantiation serves the advancement of the collaborative practices for building Shared Understanding in heterogeneous groups.

From a theoretical point of view, two major issues have been assessed. First of all, it is of interest, if the applied collaboration techniques were able to evoke the three team learning mechanisms (construction, co-construction and constructive conflict), as they have been identified as determinants for Shared Understanding. Table 2 shows the average values on all three learning behaviors on a 7 point Likert scale among all 36 participants that were measured using the items proposed by van den Bossche et al. (2011) (1=do not agree at all, 7=fully agree). It can be noted, that all constructs got very high ratings, significantly above the neutral value 4 in a one-sample t-test (T), while no significant differences between experienced and inexperienced participants or between different teams could be detected.

	Average	N	SD	T
Construction	6.3889	36	0.61075	23.468***
Co-construction	6.1481	36	0.66402	19.411***
Constructive Conflict	5.9375	36	0.70553	16.477***

Table 2. Team Learning Behaviors (7 point Likert response format, ***p<0.001)
Source: Own representation

As the team learning behaviors are only means to evoke Shared Understanding in the theoretical framework we use, the change in Shared Understanding has to be monitored as well to assess the effect of the techniques. We collected to self-assessment measures of Shared Understanding in a survey questionnaire in the beginning and in the end of the workshop. Shared knowledge has been assessed by the question "To what extent does your group have similar knowledge on [name of the work task that should be documented]?" (1=none; 5=very much). Differences in knowledge were assessed by the question "To what extent does your own knowledge on [name of the work task that should be documented] differ from the knowledge of your fellow team members?" (1=not at all; 5=very much).

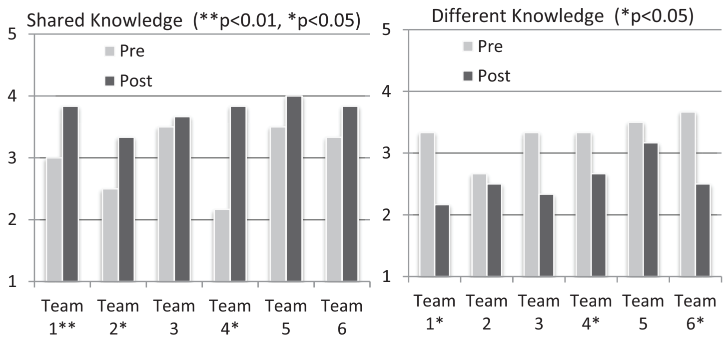

Figure 2. Changes of Shared Knowledge and Different Knowledge
Source: Own representation

Figure 2 shows that, however, the teams started with different levels of perceived shared knowledge and different knowledge, all teams experienced a substantial improvement of those measures. Table 3 displays, how the measures for shared knowledge and different knowledge among the members of each group change from pretest to posttest. Shared knowledge increased significantly from a mean of 3.0000 to 3.7500, while differences of knowledge decreased from 3.3056 to 2.5556.

This self-assessment of the participants goes in line with our expectation, that construction, co-construction and constructive conflict in the collaboration process are related to an increase of Shared Understanding.

		Average	N	SD	Change	T
Shared Knowledge	pre	3.0000	36	0.71714	-0.75000	5.147***
	post	3.7500	36	0.64918		
Different Knowledge	pre	3.3056	36	0.88864	0.75000	4.652***
	post	2.5556	36	0.84327		

Table 3. Changes in Shared Knowledge and Different Knowledge (5 point Likert response format, ***p<0.001)
Source: Own representation

As self-assessed changes in Shared Understanding may be biased and only reflect a perceived development, we used the changes in the work process documentation the participants generated throughout the workshop as a complementary method to evaluate the evolution of Shared Understanding.

Table 4 reports the number of unique activities mentioned in the work process documentation by each individual after activity A2 (Fig. 1), pairwise after A8, (Fig. 1) and group document resulting from A14, (Fig. 1), e.g. “retrieve data”, “roughen component” etc. Furthermore, the increase (+) and loss (-) in number of constructs from individual to pairwise and from pairwise to groupwise documentation is displayed. This evaluation is based on data from five teams, as we changed the form of process documentation after the first team to improve clarity and process smoothness, which hindered comparability of the documents.

		individual	pair-individual	pair	group-pair	group
Group 2	non-exp. 1	15	+ 42	57	+ 28	85
	exp. 2	24	+ 33			
	non-exp. 3	0	+ 70	70	+ 15	
	exp. 4	15	+ 55			
	non-exp. 5	12	+ 37	49	+ 36	
	exp. 6	25	+ 24			
Group 3	non-exp. 7	52	+ 18	70	+ 9	79
	exp. 8	65	+ 5			
	non-exp. 9	48	- 1	47	+ 32	
	exp. 10	15	+ 32			
	non-exp. 11	44	+ 22	66	+ 13	
	exp. 12	55	+ 11			
Group 4	non-exp. 13	29	+ 36	65	+ 22	87
	exp. 14	49	+ 16			
	non-exp. 15	17	+ 36	53	+ 34	
	exp. 16	26	+ 27			
	non-exp. 17	16	+ 22	38	+ 49	
	exp. 18	36	+ 2			
Group 5	non-exp. 19	57	+ 26	83	+ 23	106
	exp. 20	80	+ 3			
	non-exp. 21	39	+ 27	66	+ 40	
	exp. 22	31	+ 35			
	non-exp. 23	18	+ 46	64	+ 42	
	exp. 24	54	+ 10			
Group 6	non-exp. 25	60	+ 10	70	+ 13	83
	exp. 26	65	+ 5			
	non-exp. 27	54	+ 11	65	+ 18	
	exp. 28	57	+ 8			
	non-exp. 29	27	+ 23	50	+ 33	
	exp. 30	28	+ 22			

Table 4. Changes in Mental Models – Number of Constructs in Work Process Documentation
Source: Own representation

7.7 Specifying Learning

Formally the last phase of action research, the documentation and interpretation of findings is in fact executed continually throughout the process. Knowledge that has been generated in the intervention and evaluation can be applied immediately in the diagnosis phase of the next cycle due to the open, exploratory research design. Thus, we made several adaptations to the collaboration process design after the first cycle. First, the initial participants documented their work process on flipchart sheets. As participants frequently wanted to change the order of their sequence or wanted to insert further activities, later teams worked with individual paper cards for each activity in the work process. This visualization aid also proved better, when pair wise and group wise documentations were created, as it was easier for team members to make sure to consider all activities and saved time, as descriptions did not have to be built from scratch.

The second process adaption concerned an evaluation activity, which was initially executed after A9, but was left out in the revised design. Participants had been asked to reflect on the differences of their own pair's documentation in comparison to the other two. They should indicate on a Likert Scale, how much each other documentation conflicts with their own understanding of the work process. It turned out, that participants were not happy with this global level of evaluation and that we could not identify a recognizable impact on the further discussion. Therefore, it was omitted.

In further iterations, no major changes to the design had to be made. We observed that all teams acted relatively similar and followed the process design. Evaluation indicates that team learning behaviors could be evoked in every group and measures of shared knowledge and Shared Understanding developed positively. Several trends become apparent: First of all, in most cases the number of constructs increases substantially from individual to pairwise to group documentation. As participants showed commitment to their pair and group solutions, we come to the conclusion, that the understanding of the work process became more detailed and elaborate throughout the workshop. Even very experienced participants, who have been executing the work process for decades, were not able to explicate and write down all relevant process steps initially. New activities that had not been mentioned by any individual came up in the construction, co-construction and constructive conflict phases. This observation indicates that the team learning behaviors evoke mutual learning and that experienced participants can as well benefit from the collaborative effort due to questioning and reflection. Second, in most pairs, the experienced participants (exp.) contributed more constructs initially, while their less experienced co-workers (non-exp.) adopted more new constructs, when a pairwise description was developed. In two pairs of groups three and five, the non-expert contributed more than the expert. Both experienced participants noted in this situation, that they found it hard to explicate their knowledge and that they benefitted from the impulses and questions given by their colleagues. High values of pretest shared knowledge in both teams indicate that inexperienced members of those teams already had an idea of the work process, which could be verified in interaction with the experienced colleague, who was thus fostered to explicate his knowledge.

We conclude that getting involved in the collaboration process as it is described here led to construction, co-construction and constructive conflict as well as more

Shared Understanding among the team members. Inexperienced participants in general started with less detailed mental models of the work process, which were refined and complemented within the collaborative phases. Experienced participants had more advanced individual documentation, but gained further insights from the different approaches of their colleagues. Especially, they reported that the critical questions by inexperienced colleagues made them think about how to explicate their tacit knowledge. Furthermore, some of them reported that the interaction made them aware of some activities they forgot to document as well as of the existence of different approaches within their work group. The formal evaluation goes hand in hand with oral reports by several participants, who had the impression that they learned a lot from each other and that the group work was advantageous for their understanding.

7.8 Implications, Limitations and Future Research

To overcome the challenges in heterogeneous teams we used the action research approach to build a repeatable collaboration process to improve Shared Understanding.

The evaluation showed that the team learning behaviors construction, co-construction and constructive conflict occurred as intended. That leads to the conclusion that the applied collaboration techniques are a good means to evoke mechanisms leading to Shared Understanding. Furthermore, Shared Understanding could be increased, which became evident in the self-assessment of the participants as well as the changes in the working documents that reflect participants' mental models of the task. Both are indicators that the collaboration process design works and has the intended effects. Pairing of experienced and inexperienced co-workers seems advantageous for mutual learning.

This paper contributes to Collaboration Engineering practice by solving a specific problem in the organization and developing a pilot collaboration process design for Shared Understanding. The general process design can assist practitioners in building Shared Understanding in heterogeneous group work settings for complex tasks. Furthermore, we contribute to collaboration research by applying van den Bossche et al.'s (2011) model to guide design efforts. The application gives first insights on the mechanisms leading to Shared Understanding in groups of experienced and inexperienced workers.

However, the findings need to be interpreted in the light of exploratory action research design. The study was executed in one specific real world setting. Future applications in different settings could add to the understanding of mechanisms leading to Shared Understanding. For example, different combinations of experienced and inexperienced participants could be compared to identify an optimal degree of heterogeneity or different types of diversity could be explored. While the focus of this paper was on qualitative exploration of the phenomenon and design, data on Shared Understanding and team effectiveness, which has been collected after the workshop, should be used in future work to test the causal model. In this course, the assessment of the individual and team cognitive maps should be further extended. As work process documentation was mostly linear in the case at hand, we focused on the number of constructs, and excluded order and structure. They should be included in future research. In the real world situation, no control group was available to test for other influences than by the deliberate design choices. Therefore, no direct attribution of team learning behaviors to individual activities and design choices is possible at this stage. Also, alternative influences on the observed behaviors and Shared Understanding could not be controlled for, such as e.g. the influence of time spent together. Evaluation of the isolated collaboration techniques in an experimental setting could overcome those limitations in future work.

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8 Creating Shared Understanding in heterogeneous work groups – Why it matters and how to achieve it

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Abstract: Shared Understanding has been claimed crucial for effective collaboration by researchers and practitioners. Heterogeneity in work groups even strengthens the challenge of integrating understanding among diverse group members. Nevertheless Shared Understanding and especially its formation are largely unexplored. After conceptualizing Shared Understanding we apply Collaboration Engineering to derive a validated collaboration process module (compound thinkLet “MindMerger”) to systematically support heterogeneous work groups in building Shared Understanding. We conduct a large scale action research study at a German car manufacturing company. The evaluation indicates that with the use of MindMerger, team learning behaviors occur, and Shared Understanding of the tasks in complex work processes increases among experience diverse tool and dye makers. Thus, the validated compound thinkLet MindMerger provides designers of collaborative work practices with a reusable module of activities to solve clarification issues in group work early on. Furthermore, learnings from the field study contribute to the conceptualization of the largely unexplored phenomenon of Shared Understanding and its formation.

Key words: Collaboration Engineering, Shared Understanding, Knowledge Integration, Heterogeneous Groups, thinkLet

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8.1 Introduction

Due to their complexity, many tasks in organizations exceed the cognitive capabilities of any individual and thus rely on the collaboration of heterogeneous, cross-disciplinary groups (Fischer 2000; Langan-Fox et al. 2004). Previous research shows that under certain conditions, diverse groups can perform better on complex tasks than do homogeneous groups (Canon-Bowers et al. 2000; Wegge et al. 2008). While group members usually do not need to have expertise in all fields tackled by a complex project, "they have to be able to integrate their knowledge bases in a sensible manner" (Kleinsmann et al. 2010). We refer to this phenomenon as Shared Understanding. Building a Shared Understanding "is important because people frequently use the same label for different concepts, and use different labels for the same concepts. People on a team also frequently use labels and concepts that are unfamiliar to others on the team" (de Vreede et al. 2009). Differences in meaning assigned to key concepts, in mental models or in information can interfere with productivity of collaborative work if they are not clarified early on (Kleinsmann and Valkenburg 2008; Kleinsmann et al. 2010; Mohammed et al. 2010). In their recent study, Piirainen et al. (Piirainen et al. 2012) identify building a Shared Understanding as one of five critical challenges of collaborative design from design science literature and practice, especially in the early problem definition and artifact construction phases. This challenge can be complicated due to e.g. a lack of overlap in experience, shared context and language of the actors, the wicked, ambiguous nature of design problems, or the disruption of routines, which influences how a group forms and performs (Garfield and Dennis 2013).

There is ample evidence of the positive effects of Shared Understanding discussed in prior work, e.g., on performance (quality and quantity of results) (Mathieu et al. 2000; Langan-Fox et al. 2004), group member satisfaction (Langan-Fox et al. 2004), co-ordination of activities among group members (Hsieh 2006), reduction of iterative loops and re-work (Kleinsmann et al. 2010), innovation (Kleinsmann and Valkenburg 2008) or team morale (Darch et al. 2009). If techniques and processes can be designed that predictably support the creation of Shared Understanding in heterogeneous groups, these groups are expected to gain efficiency in their work and produce better results (Mohammed et al. 2010).

As little is known on what leads to Shared Understanding, practitioners need guidance on how to evoke processes for Shared Understanding deliberately and repeatedly. Collaboration Engineering, as an approach to designing and deploying reusable work practices for high-value recurring tasks without the ongoing intervention of a professional facilitator (de Vreede et al. 2009), has identified “clarify” – the process of moving from less to more Shared Understanding – as one of six recurring patterns of collaboration (Briggs et al. 2006). There has been a lot of fruitful research on other patterns, e.g., generate (Shepherd et al. 1995; Reinig et al. 2007) and build consensus (Kolfschoten et al. 2009) that has led to theories (Briggs 1994; Briggs et al. 2008; Briggs and Reinig 2010) and to validated standardized facilitation techniques (thinkLets (Briggs and de Vreede 2009)) that “can be used as conceptual building blocks in the design of collaboration processes” (Kolfschoten et al. 2006).

Little attention, however, has been paid to the “clarify” pattern to-date, and Shared Understanding as a core construct within the clarify pattern still is a fuzzy phenomenon subject to conceptual confusion (Akkerman et al. 2007). It would thus be valuable to gain deeper understanding of the clarify pattern of collaboration in order to (1) provide collaboration engineers with documented work practices to be reused in their own designs, (2) enrich exploratory research on Shared Understanding from related disciplines with a Collaboration Engineering perspective and (3) contribute to clarification of the fuzzy construct of Shared Understanding.

We therefore (1) conceptualize Shared Understanding and theorize on an initial frame of potential determinants and effects of Shared Understanding, (2) use these theoretical approaches to inform the development of a repeatable collaboration process module that leads to better Shared Understanding in group work and thus to better group results and (3) validate empirically the designed collaboration process module for Shared Understanding while exploring the research frame. We propose a collaboration process module for Shared Understanding that can be used by designers of collaboration processes to repeatably evoke the clarify pattern. We use the thinkLet (Briggs and de Vreede 2009) notation and logic, documenting the collaboration process module in the form of a compound thinkLet: a larger, predefined sequence composed of several packaged thinkLets.

While a basic version of the process logic itself has been proposed earlier (Bittner and Leimeister 2013), this paper expounds on using and advancing the compound thinkLet MindMerger in the challenge of Shared Understanding and knowledge integration in heterogeneous work groups in a real world setting at a German automobile manufacturing company (Bittner et al. 2013). We chose an action research approach to develop a solution for the specific practical problem situation, while simultaneously investigating the phenomenon of Shared Understanding and knowledge integration in heterogeneous teams. By advancing and validating the compound thinkLet in a real world setting, we cautiously generate new insights on the mechanisms leading to Shared Understanding in heterogeneous group works.

The rest of the paper is organized as follows: First, we point out our underlying conceptualization of the fundamentals of Shared Understanding, including a new definition of the phenomenon. The next section describes the action research approach we use within the design research process and the Collaboration Engineering methods applied. Afterwards, we outline the action research phases with the thinkLet development and validation in the real world setting. The findings are discussed with respect to the design and lessons learned for Shared Understanding theory development. The paper closes with a consideration of implications, limitations and outlook on future research.

8.2 Related Work – Fundamentals of Shared Understanding

Confusion exists in the literature on the definition of Shared Understanding, its antecedents and effects, as well as how Shared Understanding can be operationalized and measured. Due to the broad consideration from different research perspectives, no single widely accepted definition has been established (Mohammed et al. 2010; Bittner and Leimeister 2013). Due to a lack of validated explanatory models for Shared Understanding, we review potential constructs and mechanisms related to Shared Understanding in order to derive initial clues for design.

8.2.1 Shared Understanding

Shared Understanding and related terms (e.g., shared mental models, team mental models, group cognition, sense making, etc.) are used and defined in different ways in different research streams. Previous definitions include, among others, “the ability of multiple agents to coordinate their behaviors with respect to each other in order to support the realization of common goals or objectives” (Smart et al. 2009) or “mutual knowledge, mutual beliefs, and mutual assumptions” (Mulder and Swaak 2002).

Sharedness encompasses various aspects, e.g., "similarity, agreement, convergence, compatibility, commonality, consensus, consistency, and overlap" (Mohammed et al. 2010). Two differing interpretations of "shared" can be found, namely, shared as the joint possession of some resources versus the division of a resource between multiple recipients (Smart et al. 2009). While the latter refers, e.g., to the distribution of tasks or knowledge among different people, the former covers the phenomenon we see in Shared Understanding. Groups who are engaged in collaborative work need to have some knowledge and understanding in common, which functions as a joint reference base in order to work productively. Thus, we focus the definition of "shared" for our purpose as a resource being possessed jointly by several people. A definition of Shared Understanding should reflect this view.

"Understanding is an ability to exploit bodies of causal knowledge (i.e., knowledge about the antecedents and consequents of particular phenomena) for the purpose of accomplishing cognitive and behavioral goals" (Smart et al. 2009). This definition of understanding highlights the importance of both knowledge as facts and the structure of this knowledge. Causal knowledge is necessary for directed action towards a goal. Seeing understanding as an ability to exploit knowledge strengthens the viewpoint that understanding is more than knowledge, but a cognitive state of the knower. As an ability, understanding is not static, but a dynamic state that can change over time due to, e.g., learning.

As individual understanding is a dynamic state and sharedness is grounded in the concept of joint possession of resources, Shared Understanding is based on "the overlap of understanding and concepts among group members" (Mulder and Swaak 2002). It is thus a dynamic state of the group related to some object of knowledge that can take continuous levels. The object of knowledge can be of various structures and contents, e.g., the group task, process, or technology used. Research on the "build commitment" pattern of collaboration has identified five categories of sources of a lack in consensus closely related to domains for Shared Understanding: differences in the meaning assigned to words, different mental models, information differences, differences in individual goals and differences in taste (Kolfschoten et al. 2009; Hoffmann et al. 2013). The first three categories are also common domains of Shared Understanding. Shared meaning is the degree to which group members interpret a concept in the same, of a number of possible ways. Shared mental models refer to the degree to which mental models of cause and effect are similar among group members. Shared information means the degree to which people in a group concur on the value of the properties of things in which they are interested.

We exclude the other two categories from our scope of Shared Understanding, as our focus is on collaboration towards a group goal. A group might be working effectively towards a group goal although individual goals are different. Mutual understanding of private goals as the degree to which group members comprehend the private goals that motivate teammates to work towards the group goal might increase Shared Understanding, but shared goals are not a prerequisite. Differences in taste are closely related to individual goals. Knowing about the goals and taste of other group members can be beneficial for negotiating consensus, but if the individual goals all harmonize with the group goal, no shared individual goals are required for Shared Understanding.

Taking the above into consideration, we define Shared Understanding as *the degree to which people concur on the value of properties, the interpretation of concepts and the mental models of cause and effect with respect to an object of understanding*. For example, members of a product development team may have different assumptions on the physical values of properties of the material they are supposed to use for a new prototype such as density or heat resistance. They might interpret the same concepts differently, e.g., flexibility as bendability or as adaptability to different uses. Finally, they might diverge on their understanding of what a change in some property induced by a design choice may imply for the functioning of the whole prototype, as they assume different mechanisms and have different mental models of the whole product. All three categories of Shared Understanding may evolve gradually during collaborative work.

8.2.2 Antecedents of Shared Understanding

This section provides an overview of the current state of literature and develops a research frame on antecedents of Shared Understanding to inform the design of a compound thinkLet for Shared Understanding. As Shared Understanding is a dynamic state, factors that are positively related to an increase in Shared Understanding need to be identified. If those factors can deliberately be influenced by, e.g., staffing of the team or by evoking certain collaborative mechanisms, we will be able to design collaborative practices for Shared Understanding.

Kleinsmann et al. (2008) identify antecedents on an actor, project and company level expected to influence the construction of Shared Understanding in groups. Langan-Fox et al. (Langan-Fox et al. 2004) distinguish between individual differences and environmental factors as determinants of Shared Understanding. Among the factors related to the individual and the group are, e.g., individual personality and skills, team familiarity, authority and diversity (Pascual 1999; Kleinsmann and Valkenburg 2008). Environmental factors, such as physical proximity, incentives, communication support or organizational culture, have also been discussed (Langan-Fox et al. 2004; Deshpande et al. 2005; Hsieh 2006; Kleinsmann and Valkenburg 2008). Although the aforementioned factors should be taken into consideration by collaboration engineers, team staffing or environmental conditions are often determined by the scope of a collaboration setting, and can only be influenced to a limited extent by design. Therefore, determinants concerning the collaboration process have also been analyzed (Kleinsmann and Valkenburg 2008), such as reasoning and communication, visualized beliefs and evidences, separation of individual and shared activity spaces, and training (Mohammed and Dumville 2001; Deshpande et al. 2005; Darch et al. 2009; Du et al. 2010). Despite the broad coverage of Shared Understanding, we did not find any validated theoretical model with well-defined constructs to explain a set of antecedents to Shared Understanding. Some research has started to examine the relationship between interaction and group learning/Shared Understanding (see e.g., (Fischer and Mandl 2005; Jeong and Chi 2007)). However, a lack of knowledge can be identified concerning the specific behavioral patterns that lead to the construction of Shared Understanding and the underlying constructs (van den Bossche et al. 2011).

For the purpose of this paper, we focus on exploring team learning process variables, as they provide reference points for design choices. Mohammed et al. note that "in order for a team to achieve a shared, organized understanding of knowledge about key elements in the relevant environment, changes in the knowledge and/or behavior of team members will most likely occur. Therefore, group learning plays a significant role in the development, modification, and reinforcement of mental models" (Mohammed and Dumville 2001). This view is coherent with a constructivism perspective on knowledge and Shared Understanding. In line with Piaget (1950) and Vygotsky (1991), knowledge is constructed in the mind of the learner resulting from a learning process, where new experiences are organized and assimilated to existing cognitive structures of previous knowledge. Knowledge structures are constantly tested to fit reality.

Constructive learning theory, on the one hand, explains why different people have diverse understanding of the same reality, as knowledge is constructed within each individual. In this view, there is no objectively, right knowledge on a certain object of interest that matches reality, but rather different conceptualizations that may "fit" reality better or worse. Therefore, we work with the assumption that Shared Understanding is not per se present in a group of people receiving the same information on a certain object of understanding (e.g. group task) and it cannot be taught as universal facts. Additionally, understanding should not be assessed as right or wrong, but in relation to the other group members' conceptualization. On the other hand, constructivism provides an explanation of why Shared Understanding can evolve in a group of people who are acting in the same environment and are probably interacting. As we constantly test our understanding of a certain object against reality, our understanding will most likely assimilate if we face the same reality. Communication and interaction with other group members will have similar effects, as we might adapt knowledge structures when we face information that cannot be assimilated to our current ones. Interaction with one another and the environment will thus give impulses for changes in our understanding, and most likely produce a convergence of the group's understanding (Bodner 1986). We try to make use of these interaction mechanisms by deliberately designing processes to support the construction of Shared Understanding.

Grounded on group cognition research from learning sciences and organizational sciences, van den Bossche et al. (2011) have analyzed the construction of Shared Understanding by developing and testing a model of the team learning behaviors leading to Shared Understanding (see Figure 1). The authors examined three kinds of team learning behaviors: the effect of construction, co-construction and constructive conflict on the development of shared mental models. Further, they measured how shared mental models mediate the effect of team learning behaviors on team performance.

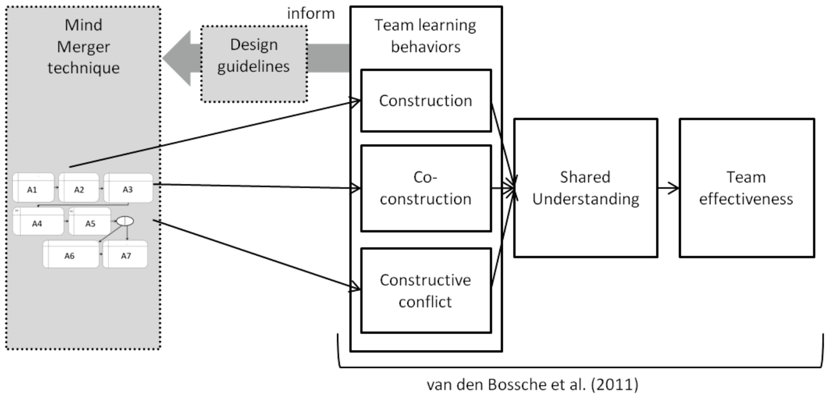

Figure 1. Theory-guided compound thinkLet development
Source: Own representation adapted from van den Bossche et al. (2011))

Construction of meaning is referred to as "when one of the team members inserts meaning by describing the problem situation and how to deal with it, hereby tuning in to fellow team-members. These fellow team-members are actively listening and trying to grasp the given explanation by using this understanding to give meaning to the situation at hand" (Webb and Palincsar 1996; van den Bossche et al. 2011). Collaborative construction (co-construction) is "a mutual process of building meaning by refining, building on, or modifying the original offer in some way" (Baker 1994). Construction and co-construction lead to mutual understanding. However, mutual understanding does not mean that group members share the same perspective or are able to act in a coordinated manner. As Shared Understanding in collaborative work is a means to acting in a coordinated manner, mutual agreement on one perspective is thus necessary. Mutual agreement is achieved through constructive conflict, which means "dealing with differences in interpretation between team members by arguments and clarifications" (van den Bossche et al. 2011).

Following van den Bossche et al.'s model, collaborative groups should express, share and listen to their individual understanding (construction), discuss and clarify them to reach mutual understanding (co-construction), as well as controversially negotiate an agreement on a mutually shared perspective (constructive conflict). Van den Bossche et al. (2011) found that these team learning behaviors positively influence the construction of shared mental models among students working on a business simulation game.

8.3 Research Approach

Our study is characterized by the framework of design science research (DSR) (Hevner et al. 2004). We followed the design science research process and completed all cycles of DSR (Hevner 2007). We studied a design process (development of the compound thinkLet), and a designed object (the compound thinkLet MindMerger). We completed the relevance cycle by identifying the construction of Shared Understanding as an important class of unsolved problems in the field. We designed and tested six iterations of MindMerger as a generalizable solution (design cycle) and took the solution back into the field to test with real problem stakeholders, completing a relevance cycle. We completed a rigor cycle by drawing on scholarly literature from group cognition and Collaboration Engineering to inform our design choices and reporting our results back to the research community. Within the design science process, we followed the standards of rigor for exploratory research and conducted an exploratory action research study with age and experience diverse groups of tool and dye makers at a large German car manufacturing company in order to generate new insights on the mechanisms leading to Shared Understanding and to develop and validate a compound thinkLet design. As Shared Understanding is a complex phenomenon in real world settings and no conclusive body of theory is available to explain the mechanisms leading to Shared Understanding and the underlying constructs, we chose an exploratory research design to allow for unexpected findings and flexible design adaption. Exploratory research allows the researcher to gather broad observations, examine the phenomenon in a holistic way and react flexibly to new insights. To allow for a holistic view and compensate for the weaknesses of individual data collection methods, a combination of several data collection methods was selected.

8.3.1 Action Research Approach

Action research was chosen as research framework for our study. Action research is a research approach from social sciences, where the researcher gets actively involved in the intervention and interacts with the members of the focal organization. On the one hand, it aims at changing the social system and solving a concrete real world problem. On the other hand, new insights into the system and the phenomenon of interest should be gathered (Baskerville 1999). Action research is characterized by a desire to proactively investigate a relatively unexplored complex phenomenon (Shared Understanding) while solving a real world problem. In a systematic cyclical process, the state of specific field situations should be understood and changed. Five phases are passed in an iterative, cyclical way, namely, diagnosis, action planning, action taking, evaluation and specifying learning (see the section on the action research study for a description of all phases).

In this paper, we followed the extended action research model by McKay and Marshall (2001), who make a distinction between a research cycle and a problem solving cycle. The two cycle approach was chosen to address the dual goal of action research as well as to counteract the critique of lacking research rigor of action research. The research cycle aims at exploring the real world phenomenon of interest to gain insights into the theoretical research framework. It leads to adding new knowledge to Shared Understanding theory. The problem solving cycle aims at improving the specific real world problem situation by using a problem solving method to execute an intervention.

In the study reported here, the problem situation exists in the challenge of supporting experience diverse work groups at a car manufacturing company to integrate and transfer their heterogeneous knowledge. The problem solving cycle results in a collaboration process design containing the MindMerger compound thinkLet for Shared Understanding as the artifact that has been developed to change the real world situation. If the problem situation is related to the phenomenon of interest and is suitable to explore the phenomenon of interest, both cycles can benefit from each other. In the section dedicated to the diagnosis of the research setting, we outline how the specific knowledge management challenge in our study qualifies as a suitable field for investigating Shared Understanding.

The dual approach is consistent with Briggs' (2006) claim to separate theory building research from the specific artifact/technological instantiation by defining separate research and engineering questions. The action research design and findings are described in the following. The piloting project with six teams allowed executing six iterative cycles. This allowed us to iteratively develop the artifact – the collaboration process design containing the compound thinkLet – from the findings of each of the six cycles. Simultaneously, insights on Shared Understanding could be accumulated from each cycle.

8.3.2 Collaboration Engineering as Design Approach for thinkLets

For developing the collaboration process and MindMerger as its core artifact, we followed the Collaboration Engineering design approach (Kolfschoten and de

Vreede 2007). Collaboration Engineering addresses the challenge of designing and deploying collaborative work practices for high value recurring tasks and transferring them to practitioners to execute for themselves without the ongoing support from a professional collaboration expert (de Vreede et al. 2009). As the construction of a Shared Understanding on ill-defined objects of knowledge is crucial for many collaborative tasks, high-value and recurring, it falls into the scope of Collaboration Engineering.

Much prior Collaboration Engineering research focuses on tasks, for e.g., generation (Shepherd et al. 1995; Briggs et al. 1997; Reinig et al. 2007) or building consensus (Kolfschoten et al. 2009; Badura et al. 2010), but little documented reusable procedures have been found on how to support the clarify pattern of collaboration (see the FastFocus thinkLet in (Briggs and de Vreede 2009) for a thinkLet aiming at clarification). Following Briggs (Briggs et al. 2006), to clarify means to "[m]ove from having less to having more Shared Understanding of concepts and of the words and phrases used to express them" (Briggs et al. 2006), and thus reflects processes for the construction of Shared Understanding. On the one hand, we use Collaboration Engineering methodology to split the task of building Shared Understanding into activities, and derive a compound thinkLet. On the other hand, we are gaining insights for the clarify pattern in Collaboration Engineering research by instantiating the MindMerger compound thinkLet in a real world setting.

8.4 An Action Research Study to Develop and Validate a compound thinkLet for Shared Understanding

8.4.1 Diagnosis of Research Setting

The authors were asked to improve the collaboration of experienced and inexperienced tool and dye makers, as well as to increase the mutual knowledge transfer to ensure the retention of tacit knowledge within the organization independent of individual people. The organization is a big German car manufacturer. The goal was to build training manuscripts that would help inexperienced workers to execute complex work tasks. As with many other organizations, this company faces an increasing challenge to enable its members to integrate diverse knowledge. Longtime employees with great experience and deep understanding of the company's processes are confronted with unfamiliar rapid technological change in their work environment. When approaching retirement age, the organization is endangered by losing the skills and tacit knowledge of these people if no appropriate means are in place to support the transfer of knowledge to new employees. New employees, on the other hand, bring an unbiased view on established work processes and recent technological education, but may lack the specific skills and expertise in highly complex fields. Young employees with recent educational knowledge and older, more experienced employees should be able to prevent critical knowledge from disappearing by learning from each other. Demographic change increases this challenge, if only a small number of young technicians are qualified to fill the positions of a big proportion of experts within the workforce who are reaching retirement age. Both experienced and inexperienced group members need to understand each other's perspective and converge on a Shared Understanding in order to work together effectively (Bittner and Leimeister 2013).

With respect to the outlined definition, Shared Understanding in this case refers to the degree to which the six members of one team concur on the work process steps (value of properties), the meaning of those steps (interpretation of concepts) and the order and relationship of the activities (mental models of cause and effect) with respect to the specific work processes they should document (object of understanding). Heterogeneity of group members becomes manifest in this setting in different dimensions, such as age, gender, formal education, work experience and duration of association with the company (see Table 1). In particular, we paid attention to the equal staffing of each group concerning members with much vs. little experience with the specific work task the group should document. 36 workers participated in the project, 5 females and 31 males. Experienced participants were on average 42.83 years old, inexperienced 23.06 years, the youngest participant being 19 years old and the oldest 57. Total job experience of the participants reached from as low as 5 weeks up to 42 years. Each of the six groups was staffed with three experienced and three less experienced workers concerning the specific work process.

		Non-Experienced	Experienced	Overall
Gender				
	Female	4	1	5
	Male	14	17	32
	Total	18	18	36
Age				
	Min	19	23	19
	Mean	23.06	42.83	32.94
	Max	30	57	57
Job Experience				
	Min	0.1	1	0.1
	Mean	5.3	23.25	14.53
	Max	14	42	42

Table 1. Demographics of heterogeneous participants
Source: Own representation

Although other aspects are also involved, this practical problem situation is well qualified as an action research field to explore the general phenomenon of Shared Understanding and validate the compound thinkLet for several reasons: 1) Heterogeneity is a feature of the team staffing, and participants have not previously worked together on a similar task in this constellation. Therefore, initial Shared Understanding on the work process that should be documented can be expected to be low (due to heterogeneous experience) as well as Shared Understanding on how to build learning material (due to the lack of experience with similar workshops). 2) The challenges of knowledge transfer, retention and generation at hand are closely related to team learning and Shared Understanding. Building a Shared Understanding on the object of the collaboration process early on may help accomplish the group goal. 3) Work process documentation is a high value and recurring task. With the MindMerger compound thinkLet at hand that is independent of the specific task, the process can be easily applied among others to similar knowledge management tasks.

8.4.2 Action Planning

In the action planning phase, the intervention to improve a problem situation is developed. We use the collaboration process design approach (Kolfschoten and De Vreede 2009) to implement the goal (improve knowledge integration and Shared Understanding on a specific work process in the group while documenting the work process collaboratively) in a collaboration process design. We split the collaboration process into a series of three one-day workshops with homework activities in between the workshops. Only part of the first workshop is discussed in this paper, as these activities are dedicated to creating Shared Understanding of the sequence of activities required in the work process, and we focus on examining Shared Understanding here. The collaboration sequence is characterized by three main phases, (1) an individual description (draft) of the craftsmen's work process, (2) integration of the individual drafts in pairs of two and (3) the integration of the pair wise drafts in one solution to which all six group members commit. In phase two and three, MindMerger is used twice.

8.4.2.1 Theory Guided Activity Decomposition

Briggs (2006) argues that grounding collaboration process design in good theory can enable unexpected success, as it can lead to non-intuitive design choices. Causal relationships described in theory provide designers of collaboration processes with hints for options they would not have considered without the theory. Good theory for design is hereby characterized by a model of causal effects, where the phenomenon of interest is the effect (in our case Shared Understanding), which should be evoked by means of a design (in our case the collaboration process). For many years the design of collaboration systems was considered more of an art than science, and successes or failures were hard to explain and repeat, as they were based on intuition and self-of-the-pants reasoning (Briggs 2006). It is the aim of Collaboration Engineering to develop predictable, reusable designs that support a class of recurring work practices. Thus, limited predictability and transferability of unsystematic approaches hinders the contribution of Collaboration Engineering work. Grounding collaboration system design in rigorous theory can help overcome these pitfalls, systematically improve collaboration research over time and point to solutions that are not intuitive (Briggs 2006).

Taking the above into consideration, we used theory motivated design (see e.g. (Leimeister et al. 2009)) to ground the design choices for the process on prior theoretical knowledge. In van den Bossche et al.'s (2011) model each team learning behavior influencing Shared Understanding is reflected in two to four items. Each item was analyzed by Bittner et al. (Bittner and Leimeister 2013) for its design implications. Every item from the model is reflected in at least one general design guideline (G1-10) (see Figure 1 and Table 2) from (Bittner and Leimeister 2013).

For example, design guideline 3 (ask questions for clarification) was derived from the item “If something is unclear, we ask each other questions” to make sure that the design allows for a questioning phase on the individual conceptualizations.

Determin.	Item	Design Guideline
Construction	Team members are listening carefully to each other	G1: Express individual understandings first
		G2: Encourage members to try to understand each individual perspective
	If something is unclear, we ask each other questions	G3: Ask questions for clarification
Co-Construction	Information from team members is complemented with information from other team members	G4: Collect individual descriptions in one shared place
	Team members elaborate on each other’s information and ideas	G5: Evaluate understanding and consistency with own perspective
	Team members draw conclusions from the ideas that are discussed in the team	G6: Proceed on differences between understand ings
Constructive Conflict	In this team, I share all relevant information and ideas I have	G7: Encourage sharing of divergent views (parallel and anonymous)
	This team tends to handle differences of opinions by addressing them directly	G8: Address differences in discussion
	Comments on ideas are acted upon	G9: Process every conflicting aspect
	Opinions and ideas of team members are verified by asking each other critical questions	G10: Allow clarification questions and conflict negotiation

Table 2. Theory based design guidelines
Source: Own representation

The process design should reflect these aspects. We focus on these antecedents for the purpose of an initial design, conscious of the fact that future research should try to identify the underlying constructs that are changed by the observable behaviors in the model. For later design iterations, other or additional antecedents presented in the related work section might be considered. The design guidelines are used to split the task (constructing Shared Understanding) into a manageable and repeatable sequence of activities.

8.4.2.2 Design Artifact Documentation – the MindMerger compound thinkLet for Shared Understanding

In this section, we present the MindMerger compound thinkLet design derived from the design guidelines through Collaboration Engineering in a generic way. Similar to established thinkLets (Kolfschoten et al. 2006; Briggs and de Vreede 2009), the design should be reusable by other collaboration engineers, who can customize it to their specific collaboration settings and to their objects of Shared Understanding. The MindMerger compound thinkLet is characterized by two main phases: (1) an individual phase for revealing and documenting the understanding of each participant on the object of knowledge and (2) the integration of the individual drafts in pairs of two or larger groups into one document, to which all participants commit. This structure reflects the goal of a shared representation of the object of knowledge at the end of the execution of MindMerger. The individual phase is based on the assumption that an individual working space and individual reflection is critical, as members need to be aware of their own mental model. An individual representation should help by encouraging individual construction of knowledge and reflection, as well as by serving as a boundary object and reminder of the aspects to discuss in the pairwise/group phase.

We recommend a pairwise phase to foster the interaction among participants with diverse knowledge. While in a larger group the experienced members could easily take over the discussion and less experienced or less extroverted people might withdraw from contributing to the group product, in pairs of two, both participants are likely to be heard. This approach seems especially promising if participants are paired that are very heterogeneous concerning their experience with the object of knowledge, their demographic characteristics or their personalities.

The collaborative phase is further divided into three sequences according to the three learning mechanisms proposed by van den Bossche et al. (2011). First, the participants try to make sense of the documents for themselves by reading their partner`s structured description of the object of knowledge (activities A1-A3, Figure 2). Second, clarification questions are collected and answered to foster the co-construction of meaning and the evolution of mutual understanding (A4). A FreeBrainstorming thinkLet (Briggs and de Vreede 2009) was adapted to the special requirements of constructing individual understanding and mutual understanding on some object of knowledge. In particular, the new FreeConstruction thinkLet (see Appendix A) accounts for in-depth clarification of more complex conceptualizations of the object of knowledge rather than broad unrelated idea collections. Furthermore, switching pages is used to ask and answer clarification questions instead of elaborating on ideas as in a FreeBrainstorming.

However, mutual understanding is not sufficient for coordinated action towards a group goal, which should follow the MindMerger compound thinkLet. As the two drafts may still differ or even contradict each other in certain aspects, a third sequence of activities aims at evoking constructive conflict. Participants are asked to identify and resolve differences as well as conflicts in a discussion before integrating their drafts into one that both agree upon. This procedure is represented in activities A5 to A8 (Figure 2), which include an adapted ReviewReflect thinkLet (Briggs and de Vreede 2009). The major adaption - included in MindMerger - results from splitting the review phase into an activity for identifying differences and another for finding conflicts, before resolving both in a discussion. A detailed description of how the specific activities are grounded in the theoretical framework of the team learning behaviors can be found in (Bittner and Leimeister 2013). Figure 2 shows MindMerger in a facilitation process model (FPM) notation. The individual activities are further detailed in Appendix A (thinkLets) and Appendix B (overall script and instructions).

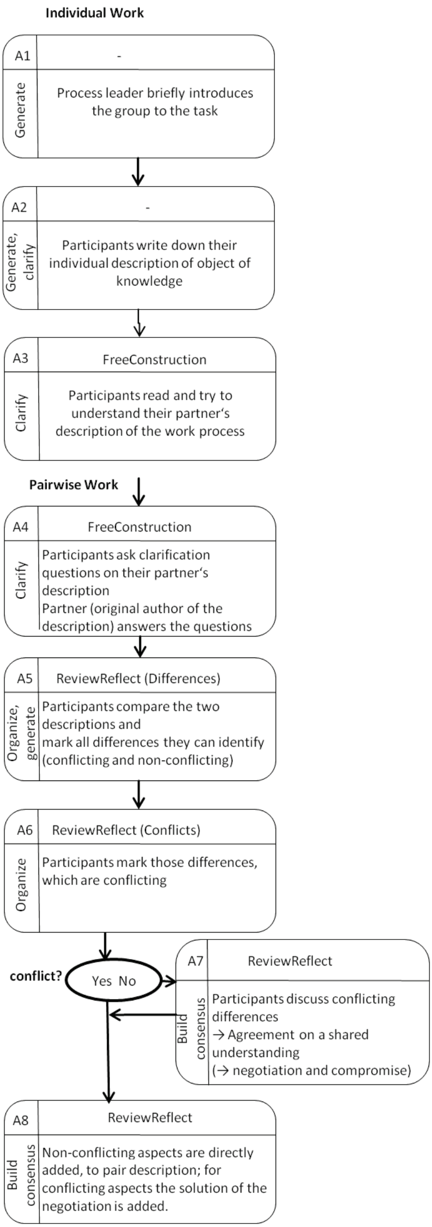

Figure 2. MindMerger - Facilitation Process Model (FPM) of compound thinkLet for the Construction of Shared Understanding
Source: Own representation

8.4.3 Action Taking

In the action taking phase, the planned intervention is executed in the field. The researcher interacts directly with the participants and actively gets involved in the changes introduced to the problem situation. For the problem solving cycle, this means that the artifact – in our case the collaboration process design with the MindMerger compound thinkLet for Shared Understanding– is pilot tested. Six pilot workshops were executed with groups of six tool and dye makers each. Each workshop lasted seven hours with a lunch break and several smaller breaks. Held in a university collaboration laboratory to release the participants from their daily routine, they were moderated by one of the authors. Another Collaboration Engineering researcher facilitated and observed the workshop process. As the action research approach demands an iterative development of the solution, the full cycles were run through for every group, and necessary adjustments were made to the process design after each cycle.

Data for gaining new insights - into the problem field as well as into Shared Understanding as the phenomenon of interest - were collected throughout each cycle. A combination of different qualitative and quantitative data collection methods was used to ensure triangulation. Both moderator and facilitator observed the group interaction and took field notes during and after each workshop. Participants were asked to fill out a standardized questionnaire before and after each workshop for self-assessment of changes in (shared) understanding and team learning behaviors. The team learning behaviors were measured by the nine items in Table 2. In the questionnaires, demographic data were collected as well as process related measures on perceived satisfaction and collaboration effectiveness. In addition, the group products - as they evolved during the process in the form of individual, pairwise and group cognitive maps - were documented for further analysis. Cognitive maps resulted from the MindMerger execution. Participants wrote down work process steps on paper cards (one activity on each card) and sorted them in chronological order as they were executed in the work process (object of knowledge). Whenever parallel or alternative work streams were possible, additional cross links were added. We will present the results and insights in an aggregated manner in the following sections.

8.4.4 Evaluation

In the fourth phase of the action research cycle, it is evaluated whether the intervention had the intended effects and whether these effects were able to improve the problem situation. In particular, we examine if the participants showed the three group learning mechanisms (construction, co-construction and constructive conflict) in the course of the collaborative process that the MindMerger compound thinkLet was meant to evoke. Further, we analyze whether Shared Understanding increases throughout the process and how the mental model of the work process of the participants will change as they move towards joint representation. For the problem solving cycle, the evaluation provides information on how far the intervention has reached the goals set for the project, e.g., concerning knowledge transfer, group cohesion or satisfaction of the participants. The practical evaluation provides an indication of the adjustments to the design that are necessary in the next problem solving cycle, as well as when the action research project can be closed. For the purpose of this paper, we focus on the evaluation for the research focus of the project. In addition to new knowledge on the research frame, insights into the phenomenon of interest are gathered. Every instantiation serves the advancement of the collaborative practices for building Shared Understanding in heterogeneous groups.

From a theoretical point of view, two major issues are addressed. First, it is of interest to ascertain whether the applied collaboration techniques were able to evoke the three team learning mechanisms (construction, co-construction and constructive conflict), since they were identified as possible determinants for Shared Understanding. Table 3 shows the average values on all three learning behaviors on a 7 point Likert scale among all 36 participants that were measured using a German version of the nine items proposed by van den Bossche et al. (2011) (1=do not agree at all, 7=fully agree), which are listed in Table 2. It can be noted that all constructs received very high ratings, significantly above the neutral value 4 in a one-sample t-test (T), while no significant differences between experienced and inexperienced participants or between different teams could be detected.

	Average	N	SD	T
Construction	6.3889	36	0.61075	23.468***
Co-construction	6.1481	36	0.66402	19.411***
Constructive Conflict	5.9375	36	0.70553	16.477***

Table 3. Team Learning Behaviors (7 point Likert response format, ***p<0.001)
Source: Own representation

Second, as the team learning behaviors are only a means to evoke Shared Understanding in the theoretical framework we use, the change in Shared Understanding has to be monitored and the effects of the techniques need to be assessed. We collected two self-assessment measures of Shared Understanding in a survey questionnaire at the beginning and the end of each workshop. Shared knowledge was assessed by the question, “To what extent does your group have similar knowledge on [name of the work task that should be documented]?” (1=none; 5=very much). Differences in knowledge were assessed by the question, “To what extent does your own knowledge on [name of the work task that should be documented] differ from the knowledge of your fellow team members?” (1=not at all; 5=very much).

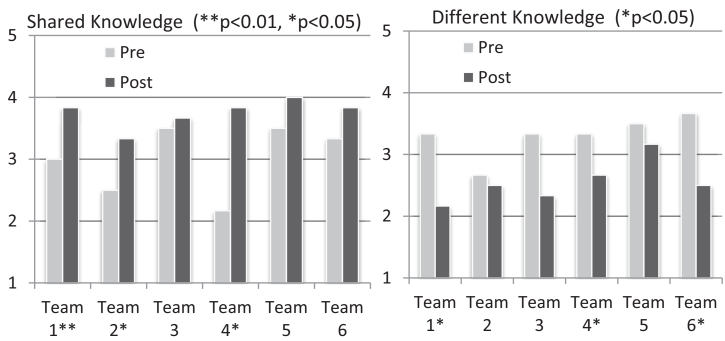

Figure 3. Changes of Shared Knowledge and Different Knowledge
Source: Own representation

Figure 3 indicates that, although the teams started with different knowledge and different levels of perceived shared knowledge, all teams experienced a substantial improvement of those measures. Table 4 shows how the measures for shared knowledge and different knowledge among the members of each group changed from pre-test to post-test. Shared knowledge increased significantly from a mean of 3.0000 to 3.7500, while differences of knowledge decreased from 3.3056 to 2.5556. This self-assessment of the participants is in line with our expectation that construction, co-construction and constructive conflict in the collaboration process may be related to an increase of Shared Understanding. However, it has to be noted that the scope and the goal of the explorative study were not to claim and test any causal relationships, but to gather rich insights into Shared Understanding and advance the compound thinkLet. For the sake of completeness, we explored the relation of Shared Understanding and team effectiveness (as proposed by van den Bossche et al. (2011)). Under the conditions described in this study, we discovered a modest, yet interesting correlation between Shared Understanding and measures of team effectiveness. Further research could be useful to more fully explore the nature of that relationship in other contexts and conditions. In this study, we used the variance-based partial least squares (PLS) approach to evaluate the proposed relationship of shared knowledge after the MindMerger use with the self-assessed team effectiveness after the completion of the whole workshop series. Different measurement points were used, as participants were expected to assess the team results better, when the process was completed and to avoid common method variance. The path weighting scheme was used as a PLS algorithm with 300 iterations. The bootstrapping procedure was used to assess the significance of the path coefficient estimates. The number of bootstrap samples was 5.000. The results of the structural model indicated that the relationship is supported and significant at a level of 0.05. Team effectiveness showed a low level of explained variance with R2 = 0.312.

		Average	N	SD	Change	T
Shared Knowledge	pre	3.0000	36	0.71714	0.75000	5.147***
	post	3.7500	36	0.64918		
Different Knowledge	pre	3.3056	36	0.88864	-0.75000	4.652***
	post	2.5556	36	0.84327		

Table 4. Changes in Shared Knowledge and Different Knowledge (5 point Likert response format, ***p<0.001)
Source: Own representation

As self-assessed changes in Shared Understanding may be biased and only reflect a perceived development, we used the changes in the work process documentation that participants generated throughout the workshop as a complementary method to evaluate the evolution of Shared Understanding. Table 5 reports the number of unique activities mentioned in the work process documentation by each individual participant after activity A2 (Figure 2), pairwise after A8, (Figure 2) and group document, e.g., “retrieve data,” “roughen component,” etc. Further, the increase (+) and decrease (-) in the number of constructs from individual to pairwise and from pairwise to group-wise documentation are displayed.

		individual	pair-individual	pair	group-pair	group
Group 2	non-exp. 1	15	+ 42	57	+ 28	85
	exp. 2	24	+ 33			
	non-exp. 3	0	+ 70	70	+ 15	
	exp. 4	15	+ 55			
	non-exp. 5	12	+ 37	49	+ 36	
	exp. 6	25	+ 24			
Group 3	non-exp. 7	52	+ 18	70	+ 9	79
	exp. 8	65	+ 5			
	non-exp. 9	48	- 1	47	+ 32	
	exp. 10	15	+ 32			
	non-exp.	44	+ 22	66	+ 13	
	exp. 12	55	+ 11			
Group 4	non-exp.	29	+ 36	65	+ 22	87
	exp. 14	49	+ 16			
	non-exp.	17	+ 36	53	+ 34	
	exp. 16	26	+ 27			
	non-exp.	16	+ 22	38	+ 49	
	exp. 18	36	+ 2			
Group 5	non-exp.	57	+ 26	83	+ 23	106
	exp. 20	80	+ 3			
	non-exp.	39	+ 27	66	+ 40	
	exp. 22	31	+ 35			
	non-exp.	18	+ 46	64	+ 42	
	exp. 24	54	+ 10			
Group 6	non-exp.	60	+ 10	70	+ 13	83
	exp. 26	65	+ 5			
	non-exp.	54	+ 11	65	+ 18	
	exp. 28	57	+ 8			
	non-exp.	27	+ 23	50	+ 33	
	exp. 30	28	+ 22			

Table 5. Changes in Shared Understanding– Number of Elements in Work Process Documentation. Experts (exp.) vs. non-experts (non-exp.)
Source: Own representation

This evaluation is based on data from five teams, as we changed the form of process documentation after the first team to improve clarity and process smoothness, which hindered comparability of the documents. Due to the different work processes to be documented in the groups, deviations in the number and structure of concepts occurred and hindered quantitative between group comparison. However, several trends became apparent: First, in most cases the number of constructs increased substantially from individual to pairwise to group documentation (Table 5). Even very experienced participants who had been executing the work process for decades were not able to explicate and write down all relevant process steps initially. New activities that had not been mentioned by any individual came up in the construction, co-construction and constructive conflict phases. This observation indicates that the team learning behaviors evoke mutual learning and that experienced participants can also benefit from the collaborative effort due to questioning and reflection. As participants showed commitment to their pair and group solutions, we come to the conclusion that the understanding of the work process became more detailed and elaborate throughout the workshops. A second trend is that in most pairs, the experienced participants (exp.) contributed more constructs initially, while their less experienced co-workers (non-exp.) adopted more new constructs when a pairwise description was developed. In two pairs of groups three and five, the non-expert contributed more than did the expert. Both experienced participants noted in this situation that they found it hard to explicate their knowledge and that they benefitted from the comments and questions given by their colleagues. High values of pretest shared knowledge in both teams indicate that inexperienced members of those teams already had an idea of the work process - which could be verified in interaction with the experienced colleague, who was thus encouraged to divulge his knowledge (Bittner et al. 2013). Inexperienced participants generally started with a less detailed mental model of the work process, which was refined and complemented within the collaborative phases. Experienced participants held more advanced individual models, but gained further insights from the different documentation of their colleagues. They reported that the critical questions by inexperienced colleagues made them think about how to explicate and communicate their tacit knowledge. Some colleagues reported that the interaction made them aware of the existence of different approaches within their work group as well as of some activities they had forgotten to document. The formal evaluation concerning team learning was confirmed by oral reports by several participants, who had the impression that they had learned a lot from one another and that the group work had been helpful for their understanding.

8.4.5 Specifying Learning

Formally, the last phase of action research - the documentation and interpretation of findings – is, in fact, executed continually throughout the process. Knowledge that has been generated in the intervention and evaluation can be applied immediately in the diagnosis phase of the next cycle due to the open, exploratory research design. We gained insights into two major issues: the compound thinkLet design itself and the potential determinants for Shared Understanding for future theory building. Table 6 summarizes the main findings and the respective research cycles from which they resulted.

Lessons for compound thinkLet Design	resulted from cycle
Individual phase critical for reflection/explication of understanding	2,3,5
Dynamic map representation of mental model rather than static list	1
Visualization/haptic boundary objects to support interaction	1,3
Reflection on specific marked differences of understanding easier than assessment on a global level	1
Lessons for Shared Understanding theory	
SU definition should cover value of properties, interpretation of concepts and mental models of cause and effect	1-6
Team learning behaviors seem to occur and can be evoked by design	1-6
Role of boundary objects and visualizations for SU needs exploration	1,4
Ideal degree of SU needs exploration	1-6
Ideal degree of heterogeneity in teams needs exploration	4-6
Potential constructs underlying construction: awareness for own understanding and visualization of individual maps	1,3,5,6
Potential constructs underlying co-construction: prior mental models, prior heterogeneity	1-6
Constructive conflict similar to negotiation/building consensus pattern of collaboration	1-6

Table 6. Findings from the action research cycles
Source: Own representation

8.4.5.1 Lessons for the compound thinkLet Design

Concerning the MindMerger design, only minor adaptions were necessary between the first two action research cycles. In particular, the initial participants documented their work process on flipchart sheets. As participants frequently wanted to change the order of their sequence or wanted to insert further activities, later teams worked with individual paper cards for each activity in the work process. This visualization aid also proved better when pair wise and group wise documentations were created, as it was easier for team members not only to ensure they had considered all activities but also to note the saved time, as descriptions did not have to be built from scratch (Bittner et al. 2013). For the general thinkLet design and potential IT support, this implies a need for flexible representation and visualization means. Depending on the object of knowledge, the workspace or group support system needs to enable participants to express elements and relations of their mental model in a well-arranged way. This finding goes in line with our definition of Shared Understanding. Issues of diverse understanding appeared to occur on different levels (information, meaning and mental models). Representations of knowledge should reflect all of those levels.

The second process adaption concerned an evaluation activity initially executed after the pairwise phase, but was left out in the revised design. Participants had been asked to reflect on the differences of their own pair's documentation in comparison to the other two. On a Likert scale they indicated how much their documentation conflicted with their own understanding of the work process. It turned out that this global level of evaluation did not provide any benefit for the collaboration process; further, we could not identify a recognizable impact on further discussions, and it was thus omitted (Bittner et al. 2013). For the general thinkLet design, we noted that discussions on very specific differences or conflicts in understanding that were marked in the documents were more effective in leading to changes in the cognitive maps than were discussions on the global work process. Especially for complex objects of knowledge, we thus propose the map-like representation.

In further iterations, no major changes to the design had to be made. We observed that all teams acted in a relatively similar manner and followed the process design. Evaluation indicates that team learning behaviors could be evoked in every group, and measures of Shared Understanding developed positively. Although generalizability is limited by the application in only one type of collaboration process, stable observations in all six teams suggests a good reproducibility of the MindMerger process and results. The increases in Shared Understanding measures and the occurrence of team learning behaviors indicate that the thinkLet may be a beneficial design module to evoke the clarify pattern.

8.4.5.2 Lessons for Shared Understanding theory

Concerning Shared Understanding theory, we observed first of all that the findings from the validation study were consistent with our definition of Shared Understanding. We were able to provide a definition of Shared Understanding that matches issues of Shared Understanding related to the value of properties (a), the interpretation of concepts (b), and the mental models of cause and effect (c) with respect to an object of understanding. Clarification could be observed on all three categories when action research participants developed joint concept maps of their work processes. Some pairs discussed: e.g., (a) what the correct values for a machine set up in a specific setting were; (b) others converged on a joint definition of what activities a certain name of a work process step covers and what it does not include; (c) Changes in the order of work process steps from the individual to joint concept maps up to complex tree structures indicated that mental models on a more structural level converged as well.

For the exploration of determinants of Shared Understanding, the empirical evaluation showed that the three team learning behaviors were reported in the questionnaires of all six groups after the use of the MindMerger compound thinkLet. This provides an indication that the MindMerger design seems to evoke those mechanisms. In combination with a rise in Shared Understanding indicators from pre-intervention to post-intervention, we conclude that our study results are consistent with van den Bossche et al.'s (2011) proposed model. However, from the literature overview and the observation of interactions within the groups, we identified a need to investigate other potential determinants in future studies. In particular, the role of boundary objects and visual explication of mental models deserves deeper consideration. We noted that participants proactively used objects from their surrounding (boxes, pens, etc.) to demonstrate certain work processes and referred strongly to the elements in the explicated concept map when discussing issues of understanding.

Further, we encountered some limitations of the theoretical model that guided our design. Team learning behaviors could be observed and measured by self-assessment, but the constructs underlying these behaviors are still unknown. Concerning construction of knowledge, awareness of own individual understanding (value of properties, interpretation of concepts and the mental models of cause and effect) may be one of the core constructs of interest that should be further investigated. This assumption is based on the observation that several participants expressed an initial difficulty to recall and explicate all elements of their work process and the order of the activities they regularly performed. Thus, one determinant of Shared Understanding development - which is evoked by construction - might be the awareness for one's own understanding of a certain object of knowledge. A second potential construct underlying construction may be availability and accessibility of a detailed (visual) representation of the individual mental model for sense making by others. The more detailed the initial individual concept maps were, the more elaborated joint concept maps were developed by the pairs.

For the co-construction behavior, potential underlying constructs are related to the degree to which certain aspects of knowledge that are new to the group members can be related to their existing knowledge frames. This perspective should be investigated in light of existing knowledge on constructive learning theory (Piaget 1950; Vygotsky 1991). We observed that the teams of which all members had at least encountered the specific work process in practice once or twice found it easier to build, combine and extend rich representations of their mental models. Teams with complete newbies or an unfamiliar external observer asking questions reported, however, that the interaction challenged the experts' established views on the process. We conclude that a maximum level of Shared Understanding might not in all cases be the optimal state. High heterogeneity - coming with a low level of initial Shared Understanding – might even foster team effectiveness in creative non-standard tasks. Optimal team staffing in the light of aspired initial and target Shared Understanding thus deserves further consideration in future work and managerial practice, as it might impact the relation of Shared Understanding and team effectiveness.

Issues related to the constructive conflict behavior are very much related to negotiating a joint perspective. Future research on the constructs associated with moving from mutual to Shared Understanding should thus try to build on theoretical work in related disciplines (e.g., on the build commitment pattern of collaboration) or from group negotiation research.

8.5 Implications, Limitations and Future Research

8.5.1 Contributions for Collaboration Engineering Research and Practice

The main contribution of this paper for Collaboration Engineering practice is a validated compound thinkLet for Shared Understanding (appendix B). This collaboration process module should be used by designers of collaborative work practices to systematically and repeatedly induce the development of Shared Understanding in heterogeneous groups. The MindMerger compound thinkLet involves a distinct and novel sequence of collaborative activities, which are designed to evoke behavioral and cognitive processes leading to Shared Understanding. Thus, the MindMerger makes use of established thinkLets, while adding a combination of collaborative procedures that have been identified as critical to Shared Understanding development, such as, e.g., individual construction and reflection followed by collaborative identification of differences in understanding. Our validation in the action research study provides an indication that MindMerger may help to evoke team learning behaviors and increase Shared Understanding among diverse group members. As Shared Understanding has been identified as crucial for collaboration success in heterogeneous groups, the compound thinkLet may foster better group processes and better results. As it is documented in a detailed thinkLet form, the MindMerger compound thinkLet can easily be applied to similar knowledge management tasks as well as to other collaborative settings where building a Shared Understanding early on is critical, such as in newly formed distributed online project teams. We furthermore contribute to Collaboration Engineering research with a deeper understanding of the thus far under-researched clarify pattern. Informed by research from related disciplines and the findings from the usage of the MindMerger compound thinkLet in a practical application, we discussed starting points for further Collaboration Engineering research. In particular, MindMerger should be applied to alternative practical collaboration situations with heterogeneous actors (e.g., requirements negotiation, design projects, strategy workshops, etc.) and tested in controlled experimental settings to overcome limitations due to the action research design. Due to the technology independent thinkLet description, instantiations with different forms of technological support (e.g., group support systems, online collaboration platforms, etc.) can easily be explored. In addition, our exploration of potential determinants and effects, as well as the conceptualization of Shared Understanding can serve as a starting point for developing more clarify thinkLets and for theorizing on an explanatory model of Shared Understanding.

8.5.2 Contribution to Group Cognition Research

With this paper, we provide a definition of Shared Understanding that builds on a review of the diverse field of previous conceptualizations. By defining three categories of domains for Shared Understanding, this definition contributes to clarify the thus far fuzzy construct Shared Understanding. While we used existing measurement items for Shared Understanding for our survey combined with open exploration, a need is revealed for more advanced measurement instruments that allow all three categories of Shared Understanding to be identified. The definition of Shared Understanding implies that measurement needs to account for gradual changes to the concurrence of the value of properties, the interpretation of concepts and the mental models of cause and effect with respect to an object of understanding. In addition, we were the first to apply van den Bossche et al.'s model (2011) of team learning behaviors to a real world collaboration process. Our findings support the relationships proposed by the model in this real world case, although we argue for future refinement of the model with its underlying constructs, including, e.g., potential roles of boundary objects, the interplay of different degrees of heterogeneity and Shared Understanding, or different types of visualization used during the team learning activities.

8.5.3 Limitations and Future Research

The exploratory action research design still poses some limitations on the findings, which should be targeted in future research. No definite conclusions on cause and effect chains between the compound thinkLet use, team learning behaviors, Shared Understanding and team effectiveness could be drawn, although findings were consistent over all groups. The action research setting allows holistic observation of realistic collaborative interaction. However, additional evaluation of the compound thinkLet and proposed theoretical relationships in an experimental setting with control groups who collaborate without the treatment will be necessary. Future research should furthermore transfer the design to practitioners to test for one of the major goals of Collaboration Engineering, execution by practitioners with reproducible results (Briggs et al. 2010). The MindMerger compound thinkLet was able to lead to stable results in this study. Application in other areas of heterogeneous groups (e.g., requirements negotiation (Hoffmann et al. 2013), strategy workshops, design projects, etc.) should further prove its generalizability and value for practice. Finally, when it comes to the important relation of heterogeneity and Shared Understanding, the optimal degree of heterogeneity in a group with respect to its ability to build a Shared Understanding deserves exploration, as well as the optimal degree of Shared Understanding a group should have on a certain object of understanding in order to collaborate effectively but maintain the benefits of diversity.

8.6 Conclusion

We present a definition and conceptualization of Shared Understanding covering different facets of this fuzzy construct. Consequently we derive a theory-motivated design of the new MindMerger compound thinkLet using Collaboration Engineering and validate it iteratively in a large-scale action research project. Following a design research paradigm, we thus contribute to solving an important class of practical problems (integrating diverse perspectives of multiple actors in heterogeneous groups) while adding new insights to the knowledge base on Shared Understanding. The validated compound thinkLet provides designers of collaborative work practices with a reusable module of activities to solve clarification issues in group work early on. Findings from the field indicate that mechanisms for Shared Understanding can be systematically evoked by our collaboration design. Although the results are stable and promising we identify a need for further investigation of mechanisms leading to Shared Understanding.

Thus, future research should aim at better understanding the complex phenomenon, its antecedents and effects thus generating more promising opportunities for developing more techniques to leverage the benefits of Shared Understanding for effective group work. We believe that organizations can use the results of this study to improve their group performance, especially in heterogeneous groups.

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Appendix A – thinkLets used in the MindMerger compund thinkLet

FreeConstruction (adapted from Free Brainstorm (Briggs and de Vreede 2009)

Choose this thinkLet...

. . . to cause the group to diverge quickly from comfortable patterns of thinking, to push them farther and farther afield in search of new ideas.
. . . to eliminate influences of other team members mental models at an early stage of reflection.
… to cause team members to reflect deeply on their individual understanding of an object of knowledge and express it.
. . . to cause team members with narrow, parochial views to quickly see the big picture, to quickly create a shared vision in a new, heterogeneous team.

Do not choose this thinkLet. .

. . . if you are pushing for breadth of unrelated ideas rather than depth in the resulting ideas,

consider using FreeBrainstorm instead.

Overview

In this thinkLet the team members' construct conceptualizations of a single object of knowledge. The team members are working on separate pages that are circulating among them. They try to make sense of each other's conceptualizations.

Outputs

One page of structured conceptualization on the object of knowledge provided by each team member which is understood by all team members.

How to use FreeConstruction

Setup

1. Create construction pages (paper based or electronic): one page for each participating team member.

2. Enter the construction question (on the object of knowledge).

<u>Steps</u>

1. Say This:

a) Please go to your individual construction page.

b) You will each start on a different page.

c) You may each sketch your understanding of the [object of knowledge]. Visualize the elements of [object of knowledge] as well as their relations, after which you must send the page back to the group.

d) You will randomly be provided with a different page.

2. That page will have somebody else's sketch on it. Please read it and try to understand it.

3. When you see a page with someone else's or your own sketch on it, you may respond in three ways:

e) If you fully understand a sketch → send it back to the group

f) If you do not understand certain aspects of the sketch → mark them and contribute a clarification question for each aspect → send it back to the group

g) If you see your own sketch → answer all open clarification questions posted → send it back to the group

4. After sending your contribution, the system will bring you to a new page. We will continue swapping pages and submitting questions and answers (Until no unanswered clarification questions are open).

Any questions? You may begin.

Modified ReviewReflect

Choose this thinkLet...

... when you must review, validate, and modify the content of an existing outline or other information structure.

Do not choose this thinkLet...

. . . when you need to generate an information structure from scratch. Consider using the BranchBuilder thinkLet instead.

Overview

In this thinkLet you adapt an existing generic text to the needs of the task at hand, or you review and comment on a deliverable document. Some thinking tasks jump off from existing content. For example, a team in an automobile factory might begin a risk assessment by considering a list of standard risks for the automobile industry. The ReviewReflect thinkLet is a way to review and tailor the existing content into something more useful for the task at hand. The thinkLet proceeds in two passes. In the first pass, all participants review and comment on the existing content. In the second pass, the participants negotiate the re-structuring and re-wording of the content.

Inputs

Pre-existing content in the form of a list, outline, or other document.

Outputs

A revised document that more closely meets the needs of the task at hand.

How to use ReviewReflect

1. Post the existing outlines.

2. Configure the tool so that comments can be annotated to each element of the outline.

3. Say this:

a) Please read each aspect of this outline and reflect about whether it is (different/conflicting) from your understanding of the [object of knowledge].

b) If you find something on the outline that differs from/conflicts with your version of it, mark it and explain why.

c) When we are finished, we will revise the outline based on your comments.

4. Allow all users to review, reflect, and comment on the outline simultaneously.

Open a new document for a joint outline. Go through all outline elements. If you…

a) …find an outline element that has no marks and comments → add this to the joint outline directly.

b) Find an outline element that has “difference” marks on it →Read the comments and say: We have several “difference” marks on this element of the outline. This means the element occurs in only some of the outlines or occurs in the outlines in different ways. Should we transfer this element to the joint outline or not?

c) …find an outline element that has “conflict marks on it → Read the comments and say: We have several “conflict” marks on this element of the outline. This means you need to find an agreement on how to treat this element. Please make a suggestion.

5. Moderate an oral discussion. Revise the joint outline as directed by the group.

6. Repeat steps 3 through 6 until all comments have been addressed.

Appendix B - MindMerger - Overall script and instructions

MindMerger - compound thinkLet for Shared Understanding

Goal:

Clarification: Move groups from a state of less Shared Understanding to more Shared Understanding of a certain object

Deliverable:

Increased the degree of SU on the object of knowledge (to enable group to work more effectively afterwards)

Participants:

Six participants per group:

- 3 experienced/knowledgeable concerning the object of interest

- 3 inexperienced/newbies concerning the object of interest

Target Participants:

Participants who are heterogeneous in their understanding of the object of knowledge, e.g., due to their demographics, training, attitude, experience, etc.

Preparation:

Specify the object of knowledge and insert in placeholders

For A2: Delete questions for processes or tasks/concepts (depending on the object)

Agenda

A1 (5 min.) Introduction

(-) [PowerPoint Slides]

Say this:

Thanks for coming. Introduce yourself and the facilitator.

Present the goal of the process, frame the object of interest (e.g., task, work process, team structure, technology, etc.)

Say this:

We'll first work individually, then in pairs and finally with the whole group. We'll use paper cards to document the structure of [object]. The session will last …

A2 (15 min.) Individual construction of meaning on the object of interest

(Step 1 of FreeConstruction) [Paper Cards]

Say this:

For processes: Please write down the process steps that need to be executed to achieve [object]. Sort the process steps chronologically in the order of their execution.

Say this:

For tasks/concepts: Please write down all aspects that characterize [object]. Sort the aspects as they relate to each other.

Say this:

Note: Please be as specific as you can about the concepts you write down so that the other participants can understand each concept by reading. Please use one card for each concept.

Transition (3 min.)

Take a photo of each card map. Ask participants to take their cards. Announce pairs (one experienced + one inexperienced participant each). Send pairs with instruction sheets to their separate workspace

A3 5 min. Pairwise construction of meaning

(Step 2 of FreeConstruction) [Paper cards, Whiteboard]

Say this:

Try to understand the concepts and structure your partner used. Why and how did he conceptualize [object] in a potentially different way than you did?

A4 15 min. Pairwise clarification of different understandings

(Step 3 of FreeConstruction) [Paper cards, sticky notes]

Say this:

a) Please read through your partner's card map individually. Which cards don't you understand? Which relationships/orders don't you understand? Please mark every card or relationship that you would like to ask a clarification question on.

Say this:

Note: Please only collect questions at this point of time. There will be time to discuss your questions with your partner soon.

Say this:

b) For the first map: Please ask your clarification question for each of the markers. Please answer your partner's clarification questions. Remove the markers for each answered question and add extra descriptions to the individual map where they help to clarify.

Say this:

Repeat b) with the second map.

Step 4 of FreeConstruction will only be executed in the second round of FreeConstruct, when 3 maps need to be matched

A5 5 min. Awareness for divergent views

(Modified ReviewReflect) [Paper cards, sticky notes]

Say this:

Please compare both your concept maps with your partner. Which differences can you identify?

Say this:

Note: Please mark all concepts and relationships that only occur in one of the two maps that should be represented in your pairwise map.

A6 5 min. Identify conflicts

(Modified ReviewReflect) [Paper cards, sticky notes]

Say this:

Which conflicts need to be resolved?

Say this:

Note: Please mark all conflicts between the two maps (conflicting concepts, wording, relationships, and order) that need to be resolved when you need to agree on one joint representation that you want to present to the group. Collect only differences and conflicts, as you will have time to search for solutions afterwards.

A7 20 min. Create joint concept map

(Modified ReviewReflect) [Paper cards, sticky notes]

Say this:

Please go through all of the cards together. Take one of the following actions:

a) If a card with the same concept exists in both maps, add both to the joint map as one concept

b) If a card is marked as "different" (occurring in only one map), discuss its place in the joint map and place it there

c) If a card is marked as conflicting, discuss which version you would like to use in the joint map

d) If a relationship is marked as conflicting, discuss which order/relationship you would like to transfer to the joint map

Transition (5 min.):

Say this:

Finalize your joint map. Prepare to present your joint concept map.

A8 Groupwise construction of meaning (second iteration of A3-A7)

(-) [Paper cards, Whiteboard]

Each pair of participants presents their concept map to the group. The group tries to understand the other maps.

Say this:

Try to understand the concepts and structure the other pairs used. Why and how did they conceptualize [object] in a potentially different way than you did?

Repeat activities A4 to A7 with the whole group of 6 participants.

9 How to improve clarification in group tasks with MindMerger and why it pays off

Eva Alice Christiane Bittner, Axel Hoffmann and Jan Marco Leimeister

Abstract: Building a Shared Understanding of the task at hand is crucial for effective collaboration. A late discovery of a lack can lead to inefficiencies and rework. However, little is known on processes leading to more Shared Understanding in newly formed working groups. Prior research mainly aims at describing factors that favor the occurrence of Shared Understanding. In this paper we investigate whether Shared Understanding can be deliberately evoked by collaboration process design and investigate whether this effort pays off in team effectiveness. We therefore present the MindMerger technique, a reusable facilitation technique to evoke team learning behaviors as a source of Shared Understanding. In this paper we discuss the results of a student experiment to evaluate the MindMerger design. We find that teams guided by the MindMerger show more team learning behaviors for clarification and higher degrees of Shared Understanding than do their team members with unstructured collaboration. Under the controlled conditions at hand, participants that used the MindMerger technique also produced better group products in expert assessment and reported more team effectiveness in their own perception. Thus, we recommend the MindMerger to designers of collaboration processes who want to make their collaborative groups more effective.

Keywords: Collaboration Engineering, Shared Understanding, thinkLet, group work, MindMerger.

9.1 Introduction

For the success or failure of collaborative work, it has been claimed that group members "have to be able to integrate their knowledge bases in a sensible manner" (Kleinsmann et al. 2010). This phenomenon is referred to as Shared Understanding, defined as the degree to which people concur on the value of properties, the interpretation of concepts and the mental models of cause and effect with respect to an object of understanding. Building a Shared Understanding "is important because people frequently use the same label for different concepts, and use different labels for the same concepts. People on a team also frequently use labels and concepts that are unfamiliar to others on the team" (de Vreede et al. 2009). In previous research there is ample evidence that a sufficient degree of Shared Understanding among collaborators on the group task is crucial for effective group work. Positive effects of Shared Understanding discussed in prior work are, e.g., on performance (quality and quantity of results) (Mathieu et al. 2000; Langan-Fox et al. 2004), group member satisfaction (Langan-Fox et al. 2004), co-ordination of activities among group members (Hsieh 2006), reduction of iterative loops and re-work (Kleinsmann et al. 2010), innovation (Kleinsmann and Valkenburg 2008) or team morale (Darch et al. 2009).

Piirainen et al. (2012) identify clarification as one of five critical challenges of collaborative design, especially in the early problem definition and artifact construction phases. This challenge can be complicated due to, e.g., a lack of overlap in experience, shared context and language of the actors, the wicked, ambiguous nature of design problems, or the disruption of routines. All of them can influence how a group forms and performs (Garfield and Dennis 2013). Often, differences in understanding are only detected incidentally in the course of group work, causing delays and rework. If an initial lack of Shared Understanding is not in the focus of the group's attention and clarification is not supported deliberately in the group forming phase, Shared Understanding may take a long time to evolve, resulting in inefficient interaction and unnecessary iterations (Hoffmann et al. 2013). We argue that by pointing out a lack of Shared Understanding early on and systematically supporting collaborative work groups with adequate clarification techniques, groups can develop more Shared Understanding and produce better results than groups can do without structured collaboration support.

As outlined above, previous research has found positive relationships between Shared Understanding and team performance. However, little is known on how to deliberately evoke the construction of Shared Understanding and its beneficial effects. We aim to close this gap by deriving collaboration techniques for clarification support following a design science paradigm (Hevner et al. 2004). As the solution maturity in this field of research is low, the design challenge is one of developing new solutions to known problems (improvement) (Gregor and Hevner 2013). Thus, this study investigates the effects of a theory motivated collaboration technique for clarification, the MindMerger (Bittner and Leimeister 2014), on Shared Understanding and team effectiveness. The MindMerger is a best practice sequence of documented thinkLet design patterns. It has been iteratively designed to evoke the team learning behaviors specified in van den Bossche et al.'s (2011) model for Shared Understanding (Bittner and Leimeister 2013) and has undergone a first practical validation in an action research field study (Bittner et al. 2013). In this paper, we evaluate the MindMerger's utility for building Shared Understanding and increasing team effectiveness as part of the design science process (Peffers et al. 2007). In an experimental setting with 34 graduate students, we tested whether teams with structured collaboration support by the MindMerger show more team learning behaviors, Shared Understanding and better team effectiveness than do teams with unsupported collaboration. Thus, we investigate, if it is beneficial for designers of collaboration processes to invest some of the often limited meeting time into deliberately building a Shared Understanding upfront. As the findings suggest, designers of collaboration systems can use the MindMerger as a building block for their collaborative work practice designs that can increase Shared Understanding and team effectiveness. Furthermore, the insights contribute to collaboration research by adding to the knowledge base on the mechanisms leading to Shared Understanding and providing general design guidelines for future collaboration process design.

The paper is structured as follows. First we give an overview of the MindMerger technique and how it is grounded in theoretical knowledge on the development of Shared Understanding. In section three, we outline the hypotheses guiding our study and the methodological approach. Section four reports the results from the experimental evaluation that are discussed in section five. Finally, we describe limitations, directions for future research and conclude with the major contributions for collaboration research and practice.

9.2 The MindMerger technique

The MindMerger is a scripted collaboration technique composed of a series of thinkLets. ThinkLets are standardized facilitation techniques, which “can be used as conceptual building blocks in the design of collaboration processes” (Kolfschoten et al. 2006). Documenting collaboration practices in a thinkLet based, standardized manner allows the design to be transferred to practitioners, who should be enabled to facilitate work processes without the ongoing intervention of a Collaboration Engineering professional.

As such, the MindMerger is a design artifact based on, and derived from, a descriptive model on team learning behaviors for Shared Understanding (van den Bossche et al. 2011). The theoretical model says that Shared Understanding can be predicted by the team learning behaviors: construction, co-construction and constructive conflicts. *Construction* of meaning is referred to as “when one of the team members inserts meaning by describing the problem situation and how to deal with it, hereby tuning in to fellow team-members. These fellow team-members are actively listening and trying to grasp the given explanation by using this understanding to give meaning to the situation at hand (van den Bossche et al. 2011). Collaborative construction (*co-construction*) is “a mutual process of building meaning by refining, building on, or modifying the original offer in some way” (Baker 1994). Construction and co-construction lead to mutual understanding. However, mutual understanding does not mean that group members share one perspective or are able to act in a coordinated manner. Furthermore, mutual agreement on one perspective is thus necessary. Mutual agreement is achieved through *constructive conflict*, which means “dealing with differences in interpretation between team members by arguments and clarifications” (van den Bossche et al. 2011). These team learning behaviors positively influence the development of Shared Understanding. Shared Understanding, in turn, has a positive impact on team effectiveness (van den Bossche et al. 2011).

Following the theory, collaborative groups should express, share and listen to their individual understanding (construction), discuss and clarify them to reach mutual understanding (co-construction), as well as controversially negotiate an agreement on a mutually shared perspective (constructive conflict). These team learning behaviors have been translated into a sequence of collaborative activities via design guidelines by Bittner and Leimeister (2013). See Figure 1 for a schematic representation of how the MindMerger was derived from van den Bossche et al.'s (2011) conceptual model.

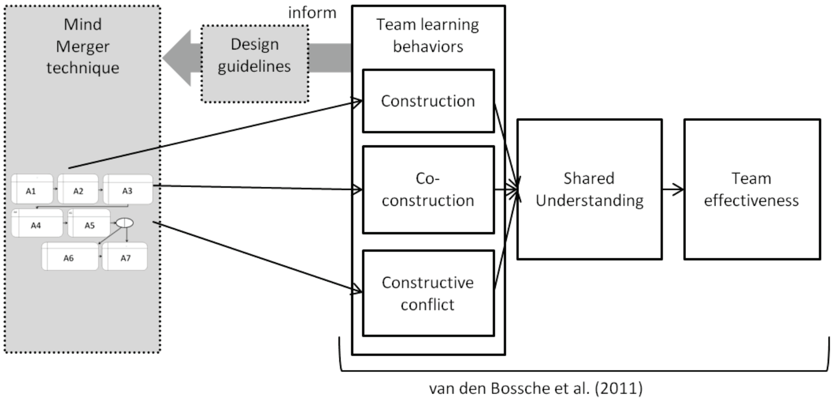


Figure 1. Interrelation of the MindMerger design and the conceptual model on Shared Understanding
Source: Own representation based on Van den Bossche, Gijselaers et al. 2011

Figure 2 shows a schematic overview of the resulting MindMerger technique with its activities for construction (A1-A2), co-construction (A3-A4) and constructive conflict (A5-A7). A short description of the activity that is executed is given in each of the boxes as well as the predominant pattern of collaboration that is evoked by it and the name of the thinkLet used. While the standard FPM notation uses one box per thinkLet, a minor adaption of the notation was used to clearly represent the origin of each activity from the design guidelines. Therefore, some thinkLets are split into more than one box. Furthermore, the process variations in case of conflicting items within the modified ReviewReflect thinkLet are modeled explicitly (for a complete documentation of the thinkLets used and an explanation of the FPM notation see Bittner and Leimeister (2014)). In A1 participants document their individual understanding on the domain of the task. A2 and A3 aim at building mutual understanding by reading each other's documentations and asking clarification questions. In the next two activities, participants mark the differences (A4) and conflicts (A5) they detect between their own and their team partner's documentation. If conflicts are found, a consensus is developed in A6. Non-conflicting aspects of both individual documentations and the newly found aspects of consensus are merged to a joint documentation in A7. A detailed description of all phases can be found in section 3.2, where the MindMerger will be applied for the evaluation that tests its usefulness for building Shared Understanding and increasing team effectiveness.

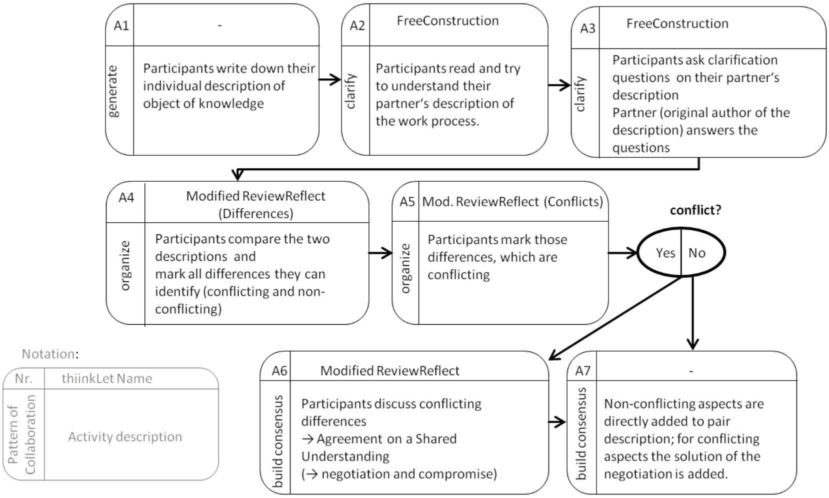


Figure 2. The MindMerger technique in an adapted facilitation process model (FPM) notation

Source: Own representation adapted from Bittner and Leimeister 2014

9.3 Methodology

The building and evaluation of the MindMerger follows a design science approach. Design science research aims at solving classes of problems or improving the situation in an application domain by developing innovative artifacts. It should, on the one hand, be grounded in a scientific knowledge base to assure scientific rigor and inform design and, on the other hand, contribute to this knowledge base. The design process itself is thus based on the interplay of scientific rigor and practical relevance, iterating through several circles of building, refining and evaluating the artifact (Hevner 2007). As outlined in section 2, the initial design of the MindMerger has been informed by prior research on Shared Understanding, in particular van den Bossche et. al.'s (2011) model on team learning behaviors. Building and refining the MindMerger technique based on design guidelines for the team learning behaviors construction, co-construction and constructive conflict (for a detailed description of the design phase see Bittner and Leimeister (2013)) has led to a validated technique that succeeded to solve practical clarification challenges (Bittner and Leimeister 2014). The focus of this paper is the evaluation phase of the design science process (Peffers et al. 2007), allowing us to derive recommendations for designers of collaborative work practices as well as contributing back general design guidelines to the Shared Understanding knowledge base. We conduct an evaluation of the MindMerger, investigating its validity and utility. Validity means that the MindMerger works and does what it is meant to do, thus implying that it is dependable in operational terms in evoking team learning behaviors and the creation of Shared Understanding. The utility criteria assess "whether the achievement of goals has value outside the development environment" (Gregor and Hevner 2013). These criteria are fulfilled if the MindMerger can be applied to improve the effectiveness of collaborative groups. In turn, the MindMerger should cause an increase in Shared Understanding to enhance team effectiveness.

9.3.1 Hypotheses

The MindMerger facilitation technique is derived from the construction, co-construction and constructive conflict team learning behaviors via design guidelines (Bittner et al. 2013) and aims at evoking all three behaviors reliably within collaborating teams (see Figure 1) (Bittner and Leimeister 2014). Therefore, it needs to be investigated whether the MindMerger design succeeds at enhancing the team learning behaviors as intended.

Hypothesis 1a: Team members guided by the MindMerger show higher degrees of construction team learning behavior than do team members with unstructured collaboration.

Hypothesis 1b: Team members guided by the MindMerger show higher degrees of co-construction team learning behavior than do team members with unstructured collaboration.

Hypothesis 1c: Team members guided by the MindMerger show higher degrees of constructive conflict team learning behavior than do team members with unstructured collaboration.

In addition to test whether the MindMerger evokes the team learning behaviors as antecedents to Shared Understanding proposed by van den Bossche et al. (2011), differences in the degree of Shared Understanding itself between the groups is of interest.

Hypothesis 2: Team members guided by the MindMerger show a higher level of Shared Understanding after the collaborative task than do team members with unstructured collaboration.

As Shared Understanding is not an end to itself, we analyze its effects on team effectiveness as well. According to the cause-and-effect chains in van den Bossche et al.'s model, we expect a positive impact of the MindMerger on team effectiveness.

Hypothesis 3: Team Members guided by the MindMerger thinkLet show higher team effectiveness than do team members with unstructured collaboration.

9.3.2 Experimental Design

In order to test the proposed hypotheses, we conducted a laboratory experiment with graduate students of a Master's course in Information Systems. Participants were assigned randomly to a treatment (MindMerger) group or a control group. Students had no prior experience with the use of thinkLets, as they had just started to learn about Collaboration Engineering foundations. Arranged into seventeen pairs, two students would work together as one team throughout the experiment. Pairwise interaction was chosen to allow tracing back the contribution of each participant as good as possible, to ensure completion of the clarification efforts within the limited amount of time available, and to prevent uncontrollable effects such as free riding in larger groups. In order to prevent pairs from interacting and influencing each other, each team was given a separate working table that was spatially isolated. The experiment lasted one hour in total. All pairs were given the task of documenting their knowledge in the Collaboration Engineering domain in a mind map representation, covering the central concepts and methods. They were asked to write down one term per box, link the boxes with arrows and add verbs to show the connection between the constructs. All instructions were written down on the worksheets to minimize influence of the individual facilitators. Both treatment and control group were supported by facilitators with two to four years of experience in facilitating groups, who had received detailed instruction on the schedule and that they should not give any prompts beyond the written script.

A questionnaire was given to the students before they started to work together and again after they completed the task. The pre-task survey covered demographic data. Additionally, the participants had to assume the degree to which they shared similar knowledge with their team partner on the subject of the Collaboration Engineering domain and the mind mapping method. The post-task survey also included the questions regarding Shared Understanding. Further, it contained items for the team learning behaviors construction, co-construction and constructive conflict as well as team effectiveness. For the survey instrument on team learning behaviors and team effectiveness, we used validated scales from van den Bossche et al.'s (2011) model. We only excluded one item of constructive conflict ("In this team, I share all relevant information and ideas I have") from analysis, as it does not seem to reflect the definition ("dealing with differences in interpretation between team members by arguments and clarifications" (van den Bossche et al. 2011)) well but rather seems to measure some willingness to disclose one's own understanding. The pre-treatment and post-treatment self-assessment questions were given in a seven-point Likert scale, requiring students to choose one of the agree/disagree items that best suited each given situation.

We used two complementary ways to assess Shared Understanding. First, a self-reported assessment of each participant should account for the individual, cognitive nature of understanding that can hardly be fully explicated in artifacts. Furthermore, we took an objective perspective by analyzing the artifacts produced by the groups in the form of mind maps, representing the team mental model the group agreed on. Therefore, we counted the terms and links in the mind maps. As with the assessment of Shared Understanding, we chose a triangulation of perspectives and measurement approaches for team effectiveness. On the one hand, we used the self-assessment proposed by van den Bossche et al. (2011) to be able to the test the entire causal model. On the other hand, we were interested in the quality of the team products with respect to the group task of teams guided by the MindMerger in comparison to those who collaborated without structured collaboration support. Therefore, we used an expert evaluation of the resulting mind maps.

The MindMerger Group was guided through the task completion process by a script with the MindMerger facilitation technique (see Table 1). Participants in the control group answered both questionnaires in a similar manner, but collaborated without structured support in between. Instead of following the MindMerger instructions outlined in Table 1, they immediately received a document with the task of developing a mind map together with their partners. The control group was given the aggregated amount of time of all MindMerger activities to prevent time effects on the group products.

Time	**Activity:** Instructions [Actions]	Data collected
0:00-0:02	**Pre-Treatment Questionnaire:** Please answer the questionnaire completely on your own. [Participants answer pre-task questionnaire],	- demographic data - self-assessed shared knowledge (baseline)
0:02-0:03	[Questionnaires are collected; worksheets are distributed]	
0:03-0:13	**Individual documentation:** Please develop a mind map on the Domain of Collaboration Engineering" on this worksheet. The mind map should cover all relevant concepts, constructs and methods, as well as their relationship to each other. [Participants write down individual mind maps]	- individual mind maps of MindMerger teams
0:13-0:16	**Pairwise clarification questions:** [Instructor collects one mind map of each pair to copy it] Please go through the remaining mind map of your partner. Try to understand the structure and content. Ask clarification questions if you come across something that you cannot read or understand. Do not try to solve any differences or detect errors in this phase; you will have time to do this later	
0:16-0:19	[Instructor returns the first mind map and collects the second]. Please repeat the clarification with the other document.	
0:19-0:22	**Individual identification of differences:** [Instructor returns copies, so that each participant has both his and his team partner's mind map]. Please work on your own. Compare both documentations and distinguish the parts of your partner's mind map that are depicted differently from your own. Please mark these concepts or links with a circle that occur in only one of the maps.	
0:22-0:25	**Individual identification of conflicts:** Now, please mark the conflicts between your own and your partner's mind map with an X. At which points do the mind maps contradict each other? Where do you agree on one viewpoint; when are you going to merge your mind maps?	
0:25-0:35	**Pairwise merger of representations:** Please go back to your team workspace. [Instructor distributes second worksheet for pairwise task] Together with your team partner, please follow the instructions on the second worksheet. Develop a mind map on the Collaboration Engineering domain on this worksheet. The mind map should cover all relevant concepts, constructs and methods, as well as their relationship to each other. Transfer all aspects that both of your mind maps have in common to your shared document. Decide collectively, whether and how to include different and conflicting aspects. [Instructor collects all worksheets]	- number of terms and links in mind maps (detailedness of team mental models) - representation of team mind maps for expert evaluation (quality of team products)
0:35-0:40	**Collection of the post-treatment self-assessment:** [Participants answer post-task questionnaire]	- self-assessed shared knowledge - self-assessed team learning behaviors - self assessed team effectiveness
After the experiment	Expert evaluation of group mind maps	- quality of team mind maps

Table 1. Experimental Agenda for MindMerger treatment group
Source: Own representation

9.3.3 Data analysis

Quantitative questionnaire analysis was used as a methodology in this study to investigate the outlined hypotheses. With the survey data of self-reported team learning behaviors, shared knowledge and team effectiveness, we conducted t-tests to compare measures of treatment and control group. Analysis of the data was carried out by means of SPSS software.

In order to complement the self-reported measures for Shared Understanding, the mind maps as group products were evaluated for their ‘detailedness’. The ‘detailedness’ was evaluated by counting relevant terms for the topic within the pairwise mind maps. While going through the maps, a list of all terms that referred to the domain of Collaboration Engineering was generated. New terms were added when they first appeared and the other maps were then searched for all concepts in the list.

As a measure for team effectiveness, expert rating was used to assess the quality of the mind maps. Three experienced lecturers and collaboration engineers on the lecture topic were selected. They were asked to rank independently the resulting pairwise mind maps of both tasks. Each expert was provided with anonymous copies of all 17 mind maps from one task in random order, so that it was not evident whether a document was from the treatment or control group. The experts were asked to sort the documents according to the degree of quality with which the map solved the group task (representing the domain of Collaboration Engineering in a mind map structure). The experts were free to build as many categories as appropriate in order to represent all nuances of quality they could distinguish. Without a time limitation, they were asked to rethink and adjust their sorting until they were satisfied with the ranking. After the expert evaluation, the quality category for each map and the resulting ranking were documented. Treatment and control groups were compared concerning the quantity of teams in each quality category and the mean rank of teams. The significance of equality of the distribution of treatment and control teams was analyzed by conducting a Mann-Whitney-U-Test in IBM SPSS Statistics Version 21, as this test does not require any assumptions on the distribution of the population. The interrater reliability assessed with Kendall concordance coefficient (Sig. < 0.001) was high ($W = 0.875$).

9.4 Results

9.4.1 Team Learning Behaviors

The first set of hypotheses explores the underlying mechanisms of the MindMerger technique. MindMerger was designed to facilitate the team learning behaviors: construction, co-construction and constructive conflict (see section 2).

Participants with the MindMerger support show higher self-reported values in team learning behaviors. To test hypotheses 1a to 1c, we compare means of the averaged scales for each individual team learning behavior (see Figure 3).

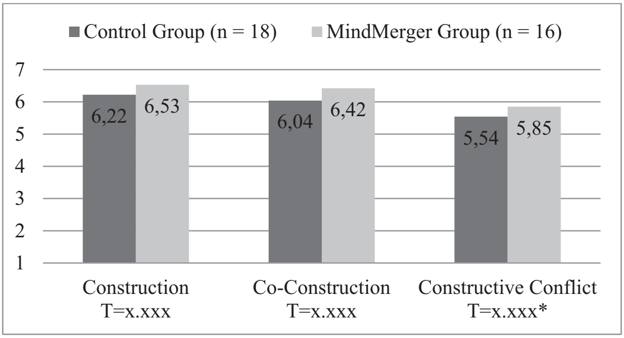


Figure 3. T-test for differences in the team learning behaviors of MindMerger and Control Group Participants
Source: Own representation

Figure 3 shows that the difference of means is significant on a 0.05 level for constructive conflict. Therefore, hypothesis 1c can be confirmed. The results provide evidence that the MindMerger succeeds to particularly evoke constructive conflict team learning behavior significantly better than does unstructured collaboration.

9.4.2 Shared Understanding

In hypotheses 2 we examine the occurrence of Shared Understanding within the pairs of participants. Therefore, we combined self-assessed measures and the evaluation of mind maps as team mental model representations the pairs agreed on.

In Figure 4, we compare the change of pre-task and post-task self-assessment of shared knowledge of the domain (left chart) and shared knowledge on the method of representation (right chart). There was no significant difference in the pre-task results for the domain knowledge (M_{CG} = 3.00; M_{MM} = 2.94; t = 0.236) and for the method knowledge (M_{CG} = 2.61; M_{MM} = 2.50; t = 0.484). As expected, the results for shared knowledge increased in the post-task survey. We could observe a clear tendency that shared knowledge on domain and method increased more in the MindMerger group than in the control group. For the domain knowledge, shared knowledge increased in the control group 0.33 (t = 1.558 n.s.) and in the MindMerger group 0.69 (t = 3,905***). For the method knowledge, it increased 0.56 (t = 2.557*) in the control group and 1.06 (t = 4.000***) in the MindMerger group. The post-task results show higher means for the MindMerger group then the control group (see Figure 4).

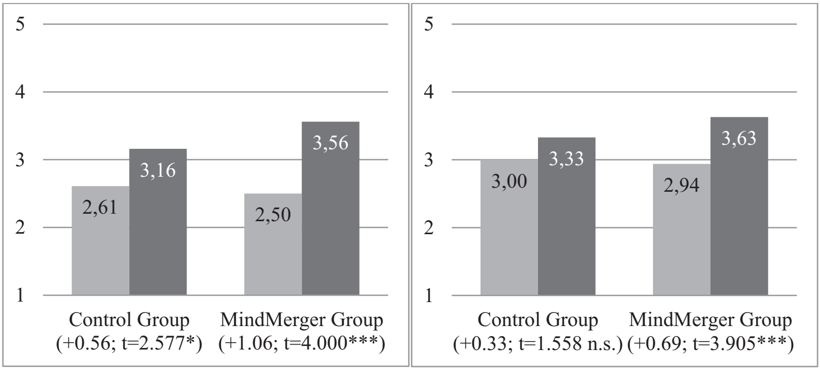
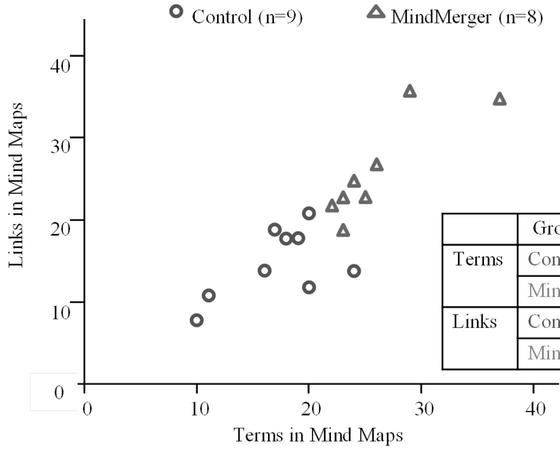


Figure 4. Results for self-assessed Shared Understanding from the pre-treatment-survey (light bar) and post-treatment-survey (dark bar).
Source: Own representation

To complement insights from Hypothesis 2, we add an objective measure for Shared Understanding. Thus, we compared the detailedness of team mind maps as a reflection of the mental model that both team partners agreed on and used them as a measure for their shared mental model. We observed that the eight teams with the MindMerger support had an average of 26.13 terms and 25.25 links in their mind map. The nine teams from the control group had on average 17.22 terms and 15.00 links. Figure 5 visualizes the results for the terms and links. The differences in the means are significant. Thus, Hypothesis 2 is supported.



	Group	Mean	T
Terms	Control	17.22	3.928***
	MindMerger	26.13	
Links	Control	15.00	4.420***
	MindMerger	25.25	

Figure 5. Results for the count of terms and links.
Source: Own representation

9.4.3 Team Effectiveness

The difference of means of team effectiveness with good reliability is significant (on a 0.005 level) with a mean of 6.27 in the Mind Merger group compared to a mean of 5.28 in the control group (Figure 6).

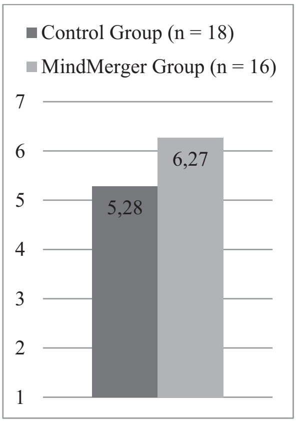


Figure 6. Self-assessed team effectiveness of MindMerger and control group (t=3,013)**
Source: Own representation

Analogously to the triangulation of Shared Understanding measurement, the internal self-assessment of team effectiveness was complemented from the external perspective. Each expert produced a ranking of all team mind maps (rank 1 = best). Expert rankings concurred strongly, with a Kendall concordance coefficient (Sig < 0.001) of 0.875. Figure 7 shows that the mean rank for mind maps from the MindMerger group was higher among all experts. Despite the relatively small number of teams in total, this tendency was significant for the first expert. The distribution in the quality categories shows that the teams in the treatment group were able to produce team mind maps that better reflected the domain content than those developed by the teams in the control group. Thus, hypothesis 3 is partly supported.

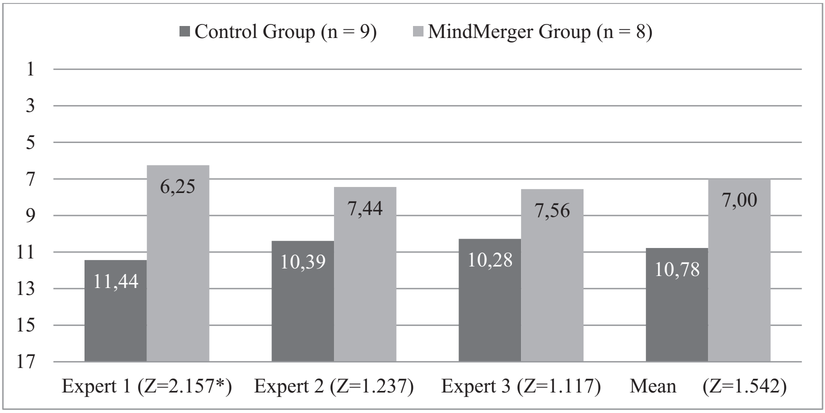


Figure 7. Comparison of mean ranks (rank 1=best) of MindMerger and control group team products (mind maps) from expert evaluation.
Source: Own representation

9.5 Discussion

The goal of this design research process was to provide a novel solution to the important challenge of building Shared Understanding in work groups, which substantially improves clarification support compared to current unstructured practices (Gregor and Hevner 2013). A design science research improvement contribution relies on a clear presentation of the new artifact (in our case the Mind Merger design described in section 2) as well as on an evaluation that provides convincing evidence of the artifact's superiority over current solutions (Gregor and Hevner 2013). The evaluation presented in this paper succeeds to show the ability of the MindMerger technique to evoke clarification and improve teamwork.

When evaluating the MindMerger use for Collaboration Engineering practice, it is of special importance that the technique is able to improve team effectiveness. In contrast to most prior descriptive studies on Shared Understanding that observe natural antecedents to Shared Understanding, the findings of this study provide guidance for designers of collaboration systems. We find evidence that using the MindMerger in the beginning of a collaborative session improve the perceived team effectiveness. Additionally, the expert evaluation showed the group products of the MindMerger teams to be superior to those of the control group.

Participants using the MindMerger also showed more Shared Understanding. Self-assessed shared knowledge on the domain and the method used increased in both MindMerger and control group after the group work. However it is indicated that participants of the treatment group perceived a stronger increase. The objective analysis of team mental model representations even shows that the mental models the MindMerger teams agreed on were more detailed than those of the control group. Thus, the MindMerger design, as a validated clarification technique, should be included into the repertoire of building blocks for the clarify pattern of collaboration. While Shared Understanding had so far mainly been a coincidental by-product of other collaborative activities, our design science project contributes a systematic, novel solution for Collaboration Engineering researchers and practitioners to complement the set of thinkLets and collaboration processes.

Participants who were guided by the facilitation technique reported more team learning behaviors than the fellow students in the control group without collaboration support. Especially the constructive conflict team learning behavior could be increased significantly through MindMerger use. As all other conditions were controlled in the experimental setting and the participants had been assigned randomly, this is an indication that the MindMerger succeeds in evoking team learning under the conditions at hand. The stable results speak for high internal validity. Thus, we were able to use van den Bossche et al.'s model to inform the MindMerger design and show that it succeeds to evoke the mechanisms it was intended to. Thus, we contribute an initial piece of design theory to van den Bossche et al.'s descriptive model of team learning to link this model to design. This is a first step towards design theory for Shared Understanding, which should be complemented by the investigation of further determinants and mechanisms.

On a more specific level, we identify three major design principles from the MindMerger technique for evoking team learning that could be used to inform further design research for clarification support.

- Participants should be supported to explicate their individual knowledge first, in order to have a boundary object to talk about with their team partners. Writing down or visualizing individual mental models can bring up terms and relations for the team discussion that would be forgotten or held back in a solely oral discussion.
- Participants should be supported to compare their individual explicated knowledge to develop mutual understanding and detect differences and conflicts
- Participants should be supported to converge on one shared document. Being forced to commit to a specific wording and structure for each term and link prevents from postponing unsolved issues and serves as a protocol of decisions for future work.

The findings are in line with Bittner and Leimeister (2014) and van den Bossche et al. (2011), who also showed that team learning causes Shared Understanding, which, in turn, can improve team effectiveness. However, we could additionally show that team learning behaviors can be deliberately evoked by design. From a comparison of supported and unsupported collaboration, we derive validation of the MindMerger design and provide guidance for designers of collaborative systems on how this facilitation technique can make groups more effective. These results provide designers of collaboration processes with a foundation for their decision on how to structure clarification processes most effectively.

9.6 Limitations and Future Research

The individual experimental study at hand is limited in its external validity due to the characteristics of experimental research. For example, we focused on one well specified and standardized group task and a sample of University students as participants. Future research should thus investigate whether the MindMerger leads to comparable results in other group and task constellations. However, the MindMerger design was utilized in a very different setting as opposed to age and experience diverse craftsmen in the original setting. Nevertheless, we find comparable levels of team learning behaviors and increased levels of Shared

Understanding, all of which provide indication for high external validity of the MindMerger design.

As different measurement approaches for Shared Understanding have led to slightly different results covering different aspects of Shared Understanding (self-reported vs. document-based), we identify a need for a unified measurement theory for Shared Understanding. Future research should replicate the study with larger groups and different kinds of participants to find out whether relationships that were not significant in the current setting are stronger in more diverse groups or with more complex tasks. Further, the impact of initial clarification on long term collaboration effectiveness deserves special investigation.

9.7 Conclusion

In contrast to most prior descriptive studies on Shared Understanding that observe natural antecedents to Shared Understanding, the findings of this study provide guidance for designers of collaboration systems. We find evidence that using the MindMerger facilitation technique at the beginning of a collaborative session can evoke team learning behaviors and increase Shared Understanding as well as team effectiveness. Especially in newly formed teams we find indication that investing time during the early phase of team work will improve understanding and build common ground.

We contribute to the theoretical knowledge base on Shared Understanding by finding support for the model by van den Bossche et al. (2011) in a new application. In a first step towards a design theory for Shared Understanding, we derive three design principles that can inform future design research efforts in this field.

Furthermore, we make a practical design science contribution to the Collaboration Engineering knowledge base by providing comparative evaluation of the MindMerger utility. Designers of collaborative work practices can use this validated building block to evoke Shared Understanding in groups. With the results of our study, we provide evidence for the potential of a technique that may possibly pay off in many settings in collaborative work practice.

Taking all of this into consideration, this paper makes contributions on all three levels of design science research proposed by Gregor and Hevner (2013):

On the first, most specific level, we document a validated instantiation of the MindMerger thinkLet that can be used and adapted by designers of collaboration systems to evoke Shared Understanding in work groups. We find evidence that this instantiation improves Shared Understanding and team effectiveness in the situation at hand.

On a second, more general level, the MindMerger technique and the design principles derived from our study serve as building blocks for Collaboration Engineering research and practice to complement the knowledge on clarification and inform the design of more techniques for Shared Understanding.

Furthermore, findings from this study contribute back to the theoretical knowledge base (level three) on Shared Understanding construction by finding evidence for some of the interaction mechanisms proposed in van den Bossche et al.'s (2011) model (especially constructive conflict) while proposing some changes to the original model (excluding one item of constructive conflict measurement). Additionally, we make recommendations for a triangulated approach to Shared Understanding measurement, which remains to be further advanced.

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10 The TANDEM Concept for Knowledge Transfer – Case Study Insights from Age and Experience Diverse Work Groups

Eva Alice Christiane Bittner and Jan Marco Leimeister

Abstract:

Purpose – The purpose of this paper is to analyze and reflect on the TANDEM workshop concept for age diverse expert-novice knowledge transfer as applied in an automotive company.
Design/methodology/approach – A case study analysis is presented to examine the expert-novice knowledge transfer interaction. We applied a triangulated approach for the collection and analysis of data, including observation, questionnaires, participants' feedback and the study of group product documents.
Findings – Findings indicate that experts and novices face different types of challenges in their interaction, and that these challenges change throughout the course of collaboration. This research shows how collaboration practices can support expert-novice knowledge transfer in age diverse groups.
Research implications –We contribute solutions to recurring challenges from the case study and link them to prior research on knowledge transfer. This study highlights the key role of social interaction in knowledge transfer of individuals that is often ignored or underestimated.
Practical implications – The collection of challenges and solutions in expert-novice knowledge transfer points designers of collaborative knowledge transfer practices to interaction issues that they will likely come across when designing for age and experience diverse groups. It provides them with validated solution approaches from the case study.
Originality/value – This paper addresses a research gap concerning good practice approaches for knowledge transfer of individuals, especially in the light of demographic change. The insights from this study can serve as guides in that process.
Keywords: Knowledge transfer, Shared Understanding, collaboration engineering, group cognition.

10.1 Introduction

In the course of demographic change, knowledge economies are faced with a major shift in the work force and are expected to encounter an even stronger change in the upcoming decades. A major trend is shaping the knowledge landscape of organizations: The work force of many developed countries is ageing and shrinking constantly (Kanfer and Ackerman 2004). For example in Germany, the generation of babyboomers (22.1 million people born between the years of 1946 and 1964) is about to reach their retirement age. A much smaller population of "Millenials" or "Generation Y" members (18.2 million people born in Germany between 1977 and 1998) is supposed to fill their positions and adopt their expertise (Emmerling 2012). From 2000 to 2025, the German workforce is expected to experience a decline of 20 percent, and the retired population will have grown by 50 percent (DeLong 2004). Other countries worldwide show similar demographic structures (Bloom and McKinnon 2010). Due to retirement or other reasons for turnovers, organizations need to deal with the challenge of enabling less qualified, young employees to take over work processes without major knowledge loss. Even if retiring employees can be replaced by young successors, the average experience level may drop rapidly, as a lifelong experience cannot be gained within a few years of training (DeLong 2004; Strack et al. 2008; Sporket 2011). On the other hand, the knowledge required to successfully execute work tasks becomes more complex due to technological progress (DeLong 2004).

Too often, complex work processes depend on the longtime expertise of single knowledge carriers, which might be lost as soon as these people leave the organization. Organizations are thus confronted with the challenge of enabling their heterogeneous and changing workforce to acquire, share and use the relevant knowledge. In order to separate knowledge intense work processes from individual knowledge carriers, organizations need to understand how knowledge transfer works and which factors foster or hinder knowledge sharing between generations of workers. "Knowledge transfer involves both the sharing of knowledge by the knowledge source and the acquisition and application of knowledge by the recipient" (Wang and Noe 2010). Prior research suggests that knowledge transfer "is better realized through mutual exchange than through a generic source-recipient model" (Argote 2005; Harvey 2012). However, Harvey (2012) notes that these interaction based knowledge transfer practices are still under-researched. Moreover, a lack of proven best practices for knowledge transfer has been identified, especially concerning specific knowledge on how people-based, interactive knowledge transfer can be organized and supported (Liyanage et al. 2009; Harvey 2012). In order to shed light on expert-novice knowledge transfer in complex real world collaboration, we explore the phenomenon in groups of diverse age and experience in a real world case study. In greater detail, we investigate what hinders and fosters knowledge transfer of experts and novices, and examine the role of structured collaboration support on knowledge transfer to derive insights for collaboration process design.

The rest of this report is structured as follows: The next section provides an overview of the related work that frames our exploratory case study investigations. Afterwards, we present the TANDEM workshop concept for knowledge transfer. We then describe the case study design where the TANDEM concept is applied, develop the case and subject description, as well as provide an outline of the procedures carried out for the collection, analysis and validity of data. Next, the results from our case study analysis are reported and evidence is provided to answer the guiding research questions. Finally, we discuss implications and limitations for managerial practice and research on knowledge transfer derived from these findings, and point out directions for future research.

10.2 Related Work

According to Kumar and Ganesh's (2009) morphology of knowledge transfer research, this study is characterized as displayed in Table 1 (see a full description of all eight dimensions in Kumar and Ganesh (2009)).

Dimension	**Characteristic of the case study**
Agents	Individuals
Study	Case study based
Flow	Internal flow
Business context	Automotive, tool building/maintenance
Geography	Within a regional cluster (site)
Mechanism	Codification and personalization
Knowledge	Explicit and tacit knowledge
Contextual factors	Social

Table 1. Morphology of knowledge transfer research
Soure: Own representation

Much prior research has investigated the phenomenon knowledge transfer in the light of transferring knowledge from one organizational unit to another. Argote and Ingram (2000) define knowledge transfer in organizations as "the process through which one unit (e.g., group, department, or division) is affected by the experience of another." The authors found broad evidence for the positive effect of an organizations ability to transfer knowledge among its organizational units on the organizational performance (Argote and Ingram 2000). However, this ability strongly varies among organizations. Less explanatory work is available to illuminate the reasons for success or failure of knowledge transfer, especially concerning interaction mechanisms on the level of individual actors (Argote and Ingram 2000). To shed light on these issues, we focus on examining knowledge transfer between ***individuals***.

The ***case study*** setting determines the focus on ***internal flow*** of knowledge, since only the interaction within one organization and no interaction with external actors is about to be analyzed. Likewise, the ***business context*** (the tool building and maintenance department of a large automotive company) and the ***geographical*** focus (one specific production site) are set. Given the central importance for this study, the dimensions ***mechanism***, ***knowledge*** and ***contextual factors*** will be discussed in detail in the following.

10.2.1 Mechanism

Two different mechanisms of "how" knowledge transfer works are prevalent in the project under study. On the one hand, participants are expected and supported to learn from each other throughout the project. This "personalization" mechanism (Kumar and Ganesh 2009) means to connect people directly and let them exchange knowledge through personal contact. Learning and knowledge integration is often a form of collaboration, as it involves social interaction. According to Briggs et al. (2006), collaboration is defined as "joint effort towards a group goal" (De Vreede and Briggs 2005; Briggs et al. 2006). In particular, the learning practices are collaborative, whereby learners are continuously interacting in small groups (joint), working together (effort) in order to achieve a shared objective (group goal) (Zhang et al. 2011). Collaborative learning can be defined as an active form of learning based on social interaction, where teaching and learning are shared experiences, teachers are acting as facilitators, and learners are taking on responsibility for their own learning and the learning of the small group in which they participate (Kirschner 2001).

Collaborative learning may be used to achieve different kinds of learning goals. Research suggests it is especially beneficial for higher order learning goals and complex tasks where groups outperform individuals (Laughlin et al. 2002; Kirschner et al. 2009). Mohammed et al. (2001) purport that “in order for a team to achieve a shared, organized understanding of knowledge about key elements in the relevant environment, changes in the knowledge and/or behavior of team members will most likely occur.” It is for this reason “that group learning plays a significant role in the development, modification, and reinforcement of mental models” (Mohammed and Dumville 2001).

From this point of view, learning is not only “a process of knowledge acquisition, but more like a process of social participation” (Guechtouli et al. 2013). This paper investigates if and how collaborative mechanisms and interaction are related to mutual learning and knowledge transfer. Thus, we are more interested in “what type of social engagement would provide an appropriate context to [collaborative learning]” (Guechtouli et al. 2013) rather than in individual cognitive processes.

The work groups in our study need to collaboratively produce work process documentations in the course of the workshop series, which are to be used as learning materials for other colleagues. Much of the communication between group members is executed via a group support system to document each conversation. This mechanism of codification is described as “connecting people to documents stored in repositories” (Kumar and Ganesh 2009). Thus, the workshop process makes use of people-based interaction to foster direct knowledge transfer (Harvey 2012) as well as aims to preserve this knowledge for further use and greater range of coverage (Guechtouli et al. 2013).

10.2.2 Knowledge

The type of knowledge involved has been identified by prior research to strongly impact knowledge transfer. In general, tacit knowledge is more difficult to transfer than is explicit knowledge, as it requires social interaction (Harvey 2012). In their recent study on knowledge sharing in teams, Hu and Randel (2014) find evidence for impact of different types of social capital among the group members on explicit and tacit knowledge sharing in teams. Hu and Randal (2014) suggest that explicit knowledge sharing may, to a large extent, impact tacit knowledge sharing. In their analysis, tacit knowledge sharing fully mediates the relationship of explicit knowledge sharing on the construct of interest, namely, team innovation. Tacit knowledge is widely discussed as being hard to detect, explicate and share (Harvey 2012). Thus, deliberately fostering tacit knowledge sharing by actively inducing explicit knowledge sharing seems to be an appealing approach. We analyze which types of knowledge are involved in the case study setting and how sharing of explicit knowledge might influence tacit knowledge sharing.

10.2.3 Contextual factors

In the light of heterogeneous workforces and demographic change, special burdens may hinder knowledge transfer. Old and young, as well as experienced and inexperienced workers diverge substantially on individual biographies of their work, education, experience and association with a company. They may rely on very different mental models, lack Shared Understanding and speak different languages, all of which may hinder knowledge transfer processes (Piirainen et al. 2012; Bittner and Leimeister 2014). Little is known, however, on how to bridge this gap in the work groups of diverse age and experience. Thus, we center this study on social factors that could influence knowledge transfer “such as the degree of cooperation between employees, shared understanding, social norms and the density and strength of network relationships” (Kumar and Ganesh 2009).

Briggs et al. (2005) and Kolfschoten et al. (2009) differentiate between five potential sources of disagreement in heterogeneous group work that are also of importance in the context of knowledge transfer, as they may impact knowledge transfer differently: differences of meaning, mental models and information, goals and taste (Briggs et al. 2005; Kolfschoten et al. 2009). “Differences of meaning occur when the same words or labels are used for different concepts or when different words or labels are used for the same concept” (Kolfschoten et al. 2009). Differences of mental models occur more on the level of cause and effect chains than on individual concepts. Both can be based on knowledge, beliefs and assumptions, whereas differences of information are defined as conflicting knowledge or knowledge that not all stakeholders might possess. Mutual understanding evolves when these sources of disagreement are revealed through asking clarification questions and communicating different views. If stakeholders agree on a common perspective of meaning, information and mental models, Shared Understanding can be reached. Two other sources of disagreement, concerning conflicts between different goals or tastes might require other consensus building strategies that focus on negotiation rather than on clarification, as they exist due to differences in outcome-instrumentality judgments (Hoffmann et al. 2013). These two sources of disagreement do not result from differences in understanding, but from mutually exclusive individual goals that hinder stakeholders from committing to a group goal or action. In this case study analysis, we investigate whether different sources of disagreement play a role in different phases of the collaborative interaction and manifest themselves in team constellations.

Boschma (2005) posits social proximity (e.g., related to trust and reciprocity) and cognitive proximity to be important potential determinants of knowledge transfer between individuals. Cognitive proximity refers to "a shared knowledge base between individuals and the capacity of these individuals to understand one another, transfer knowledge and learn from one another" (Boschma 2005). Hu and Randal (2014) identify the related construct social capital (shared cognition or Shared Understanding among the team members) as the major determinant of tacit knowledge sharing in their study. This implies that being able to build on shared knowledge, shared mental models and a shared language may foster the transfer of tacit knowledge.

Earlier work in Shared Understanding research has mainly focused on descriptive work of the relationship between interaction and Shared Understanding (see e.g., Fischer and Mandl (2005); Jeong and Chi (2007)). Some studies support the relevance of a shared reality or shared mental model of the task for a group's ability to reveal, structure and transfer knowledge (Harvey 2012). Levine, Higgins, and Choi (2000) show that instructions on the task induce groups to develop a shared reality that affects their problem-solving strategies. However, a lack of knowledge can be identified concerning the specific behavioral patterns that lead to the construction of Shared Understanding and the underlying constructs (van den Bossche et al. 2011). Bittner, Hoffmann and Leimeister (2014) have recently investigated specific behavioral patterns (van den Bossche et al. 2011) that lead to the construction of Shared Understanding to guide collaboration design efforts.

In our work, we are especially interested in the transfer of tacit knowledge from individual experts to novices. We analyze whether and how these behaviors manifest in the specific case situation at hand, where participants are aware of their own and their team partners' expert or novice role. When it comes to heterogeneous individuals, we expect some mechanisms to be of relevance other than the ones in homogeneous groups, e.g., such as: the individual ability to reveal and explicate knowledge, the relationship of experts and novices and their ability to build an initial Shared Understanding to foster knowledge transfer.

10.3 The TANDEM Workshop Concept for Knowledge Transfer

The aim of the TANDEM workshop concept is to support teams of three experienced and three inexperienced participants to individually document a work process as learning material for new colleagues. The collaborative effort should furthermore foster mutual learning and knowledge transfer of the participants involved. Each team completes a three day workshop series (kick-off, elaboration and finalization workshop) that is executed at intervals of two to four weeks.

10.3.1 Kick-off-Workshop

In the first workshop, the team develops a structure of the work process for the learning material. Participants then start to document the necessary knowledge and skills for each work process step. The kick-off workshop is structured as follows:

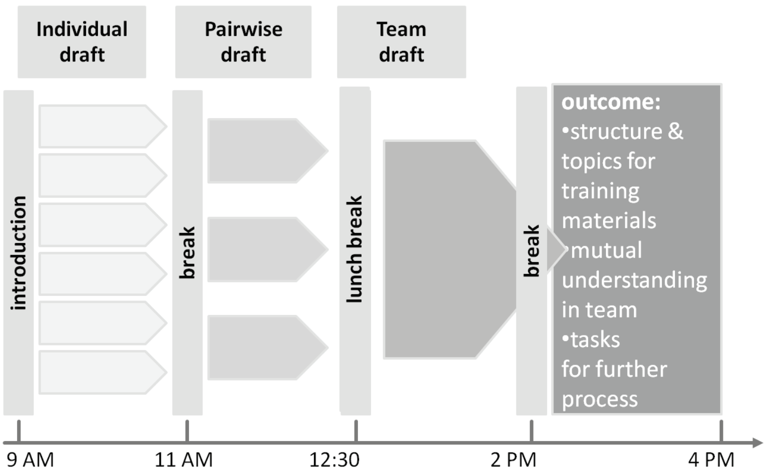

Figure 1. Structure of the first workshop
Source: Own representation

First in individual work, then in experience diverse TANDEM-pairs and finally in the whole group of six, participants develop an initial structural draft of the work process.

In the first phase of the workshop, participants write down their understanding of the work process sequence on cards, without discussing it with their team partners.

The moderator of the workshop supports participants, who have difficulties to structure or explicate the work process.

In the next phase, the MindMerger technique is used to build a shared understanding among the team members (Bittner and Leimeister 2014). Each experienced team member works together with one inexperienced team member. Both combine their work process drafts in a shared one. First, the two team members exchange their cards and try to sort their partner's work process sequence. They mark every step of the work process they do not fully understand and later on ask each other clarification questions on those issues. Annotations to the cards are made to clarify the descriptions. In the next step, TANDEM partners compare their documentations. Differences as well as conflicts between the two drafts are marked. Cards marked as differences are added to the shared documentation, as no unique process step should be lost. For cards marked as conflicting, the TANDEM partners need to discuss which alternative to choose for the shared documentation. Each TANDEM partner presents his/her solution to the rest of the team.

In the last phase of the kick-off workshop all six participants develop a team documentation of the work process together. The pairwise drafts are discussed and unclear aspects are clarified. The different solutions are compared for their differences and conflicts. Based on this discussion, the cards from all three process documentations are combined on one table. Unnecessary steps are removed and new cards are added where necessary. Finally, participants brainstorm ideas on what knowledge and skills are needed for each step, which problems may occur in each step and in which other related domains similar skills are needed.

At the end of the first workshop, the structure for the learning material has been defined and participants receive a work order to prepare for the next session: Each TANDEM should go through the work process structure at their work place and complement it with photos, manuals and descriptions.

10.3.2 Elaboration Workshop

The elaboration workshop aims at developing a clear description of each work process step in the form of a learning dialogue with supporting pictures. The workshop is structured as follows:

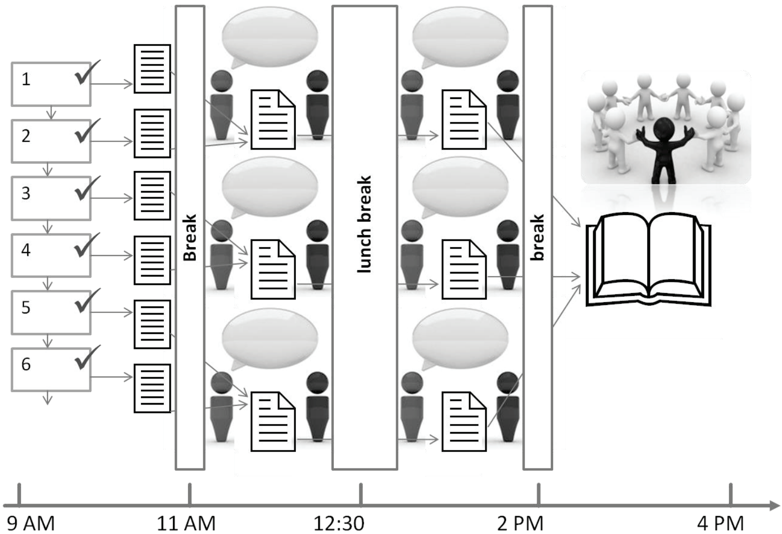

Figure 2. Structure of the second workshop
Source: Own representation

First, the moderator reads out all work process steps, and participants are to check the whole work process and assign the pictures they took as homework.

In the second phase, all participants develop an individual description of the work process steps. For this task, each participant gets a computer with the group support system (GSS) thinkTank 3 (GroupSystems) and an introduction on how to use the system. The GSS allows to synchronize contributions of all participants in real time so that everyone can see and add to each idea. The work process steps are distributed among the team members. Each participant takes short notes for his steps on which skills and what knowledge is necessary for the step. As soon as participants have completed the descriptions, they continue by checking their team partners' lists, adding ideas where required. This procedure quickly leads to a handout with the core contents of each process step as a basis for further elaboration.

In the third phase, learning dialogues are developed. The team is again split into three TANDEM pairs (one experienced and one inexperienced), and the pairs generate the learning dialogue by chatting through the GSS. The experienced partner should explain the work process to the inexperienced colleague, while the novice asks questions for clarification. If suitable, pictures are attached to visualize the descriptions.

Figure 3 displays the question-and-answer logic of the learning dialogue:

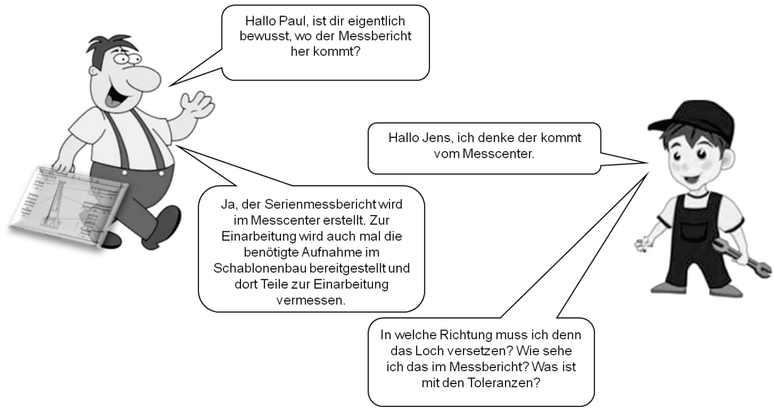

Figure 3. Excerpt from a learning dialogue
Source: Own representation

In the fourth phase, the learning dialogue sequences of all three TANDEMs are combined and each pair presents its results. The other team members comment and add to the dialogue. Gaps that cannot be addressed immediately (e.g., due to missing pictures or information) are defined as work orders for the next homework. Additionally, the participants are asked to cross-check the learning dialogue with other co-workers on site and collect their feedback before the last workshop.

10.3.3 Finalization Workshop

The goal of the final workshop is to finalize the learning material.

In the first phase, the learning dialogue is revised again. All changes proposed by the participants based on their homework are checked and the learning dialogue is complemented.

In the second phase, the TANDEM pairs design exercises for novices to practice the learning dialogue content and self-check their knowledge. TANDEM pairs mutually test their team members' exercises for their problems and clarity.

Furthermore, feedback is collected from all participants on ideas for the use of the learning material, improvement of the workshop concept and the work process.

10.4 Methodology

10.4.1 Research Questions

In order to stay open to unexpected insights from exploratory case study research, we define three relatively open guiding questions for the following investigations:

> *Which obstacles to knowledge transfer do manifest in the interaction of experts and novices?*
>
> *How are knowledge transfer challenges solved in the case study setting?*
>
> *What insights can be gained for the design of collaboration systems for expert-novice knowledge transfer?*

10.4.2 Case and Subject Selection

10.4.2.1 Case selection

The case underlying this study has been chosen due to its representativeness concerning a knowledge management challenge that many organizations face in the light of demographic change. The average age of employees in the department under study in the focal organization has risen substantially in past decades. A substantial proportion of experts is about to leave the company within the next five years. Less qualified youngsters are available to fill these positions but have only a short time for on-the-job-training. Due to fluctuations in the hiring policy, the department is also characterized by an age gap in the work force with a lack of employees aged 30 to 40. Experts with considerable tacit knowledge on the work practices and organizational processes in the last phase of their career need to collaborate and build a shared knowledge base with young, inexperienced beginners in the field. Given this case setting, we had the opportunity to examine both expert-novice and expert-expert interaction, and the situation is thus a suitable example for knowledge integration in heterogeneous teams. Further, we chose the case study, taking into account its accessibility of data. A research team was able to accompany the whole pilot project and collect data from multiple subjects and sources.

10.4.2.2 Case description

This case study covers a project on knowledge management in a large manufacturing company. Similar to many other organizations, this company faces an increasing challenge to enable its members to integrate diverse knowledge.

Longtime employees with considerable experience and deep understanding of the company's processes are confronted with unfamiliar rapid technological change in their work environment. The organization is endangered by losing the skills and tacit knowledge of people approaching retirement age if no appropriate efforts are taking place to support the transfer of knowledge to new employees. Looking at the situation from a different perspective allows recognizing that new younger employees bring with them the latest technological education and unbiased view of established work processes. However, they may lack the specific skills and expertise in highly complex fields. Young employees with recent educational knowledge and older, more experienced employees should be able to learn from each other to prevent critical knowledge from disappearing. Demographic change creates this challenge, as a large proportion of experts are reaching retirement age and only a few young technicians are qualified to fill their positions. Both experienced and inexperienced group members need to understand each other's perspective, and converge on their knowledge of the work processes in order to work together effectively.

The project has been executed in a tool building and maintenance department for complex production machines. The piloting of a collaborative workshop process aims at integrating the years of experience of diverse tool and dye makers in a workshop series. In this process, employees are guided by a trained moderator to develop training materials for pre-specified work practices from their work field in order to help inexperienced workers to execute complex work tasks. In this way, the process increases the mutual knowledge transfer to ensure that the retention of tacit knowledge within the organization remains independent of individual people.

10.4.2.3 Subject description

Heterogeneity of group members in this setting was evident in different dimensions: age, gender, formal education, work experience, duration of association with the company etc. Each group was staffed with three experienced and three inexperienced employees concerning the specific work task the group needed to document. As Table 2 indicates, 48 employees participated in the project, five females and 43 males. The average age of experienced and inexperienced participants was, respectively, 44.16 and 24.09 years, with the oldest participant being 57 and the youngest 19. The total job experience of the participants ranged from as low as five weeks to 42 years of experience.

	Non-Experienced	Experienced	Overall
Gender			
Female	4	1	5
Male	20	23	43
Total	24	24	48
Age			
Min	19	23	19
Mean	24.09	44.16	34.29
Max	35	57	57
Job Experience			
Min	0.1	1	0,1
Mean	8.88	24.42	16.81
Max	17	42	42

Table 2. Demographics of heterogeneous participants
Source: Own representation

10.4.3 Data Collection

Data for the case study were collected throughout a period of thirteen months in 2012 and 2013. In total, eight teams (of six employees each) went through the workshop process to generate a training handbook. The iterative nature of the project brought the iterative data collection and adaption of the data collection methods to new insights. Thus, a list of guiding questions for field notes was introduced in September 2012 to point the observers' attention to critical incidents in the groups' interaction. Additionally, participants of the eighth group were interviewed individually to complement the data collected from the other groups and validate the initial findings.

10.4.4 Analysis Procedure

Since we were able to follow the whole project from the beginning, we started analyzing the data from each of the eight teams directly after every workshop. The additional topics that arose in the first teams were documented and discussed regularly in the further ones. In parallel, data collection and analysis modes were adapted iteratively to match the requirements of the emerging insights. In particular, the wording of participant questionnaires and feedback questions were slightly adapted to improve clarity.

10.4.5 Validity Procedure

We addressed the aim of reaching high validity of the case study data and results through the different measures proposed by Runeson and Höst (2009). First, we applied the procedure of triangulation for the data sources, observers, data collection methods and theoretical viewpoints. The goal of triangulation is to provide a broader picture of the complex situation at hand, balancing the limitations of single rich but less precise qualitative data sources. Therefore, we collected data from multiple sources, e.g., from all participants directly, through observation by two researchers, as well as the documents generated throughout the workshops by the participants. All collected data and the interpretations were cross-checked by a second researcher who also attended the workshops. The data interpretations and deductions presented in this report were also validated by this researcher. We combined different qualitative (interviews, observations, field notes, participant feedback) and quantitative measurement approaches (participants' demographics and self-assessment questionnaires). Participant feedback notes were handled visibly for all members in the group support system. The group then discussed and commented on controversial ideas for participant validation.

10.5 Results

This section presents the results and reports our findings for the guiding research questions, indicating how they were derived from the data we collected. We outline the different types of challenges in knowledge transfer that became evident in the course of the project. We found that challenges in expert-novice interaction differ from those in expert-expert collaboration. The following section outlines findings for each of these categories. For each challenge, we discuss potential explanations from literature, provide evidence for how they are solved in different participant constellations and derive recommendations for collaboration process design.

10.5.1 Challenges in Expert-Novice Collaboration

The core idea of the workshop concept implemented was to match experts and novices in pairs to collaboratively document knowledge and exchange knowledge in the meantime. However, these expert-novice pairs faced specific challenges in their interaction. We observed that the interaction of experienced and inexperienced participants exposed different types of misunderstandings compared to the interaction of experienced workers with one another.

10.5.1.1 Experts' challenge to estimate novices' knowledge state

The first challenge the experts encountered was to estimate the level of knowledge their inexperienced peers possessed, the aim of which was to choose the right level of complexity and detail for their communication. As the experts themselves were all very familiar with the work process and most had not worked with the novices on the specific task before, they had no prior information on the novices' knowledge state. However, it was crucial to build on the prior knowledge base of novices exactly in order to create meaningful learning materials. At the same time, complexity and detail of information should neither be too low and trivial nor too high for novices to relate it to their mental models.

The experts' problem to assess the novices knowledge may partly be explained by the low codifiability and high tacitness of the work process knowledge at hand (Zander and Kogut 1995; Martin and Salomon 2003). It is important to realize that at that time the knowledge on the work process existed only in the minds and the skills of the individual participants and had never needed to be explicitly written down before. Furthermore, experts had a blind spot for the specific learning needs of novices due to their unrevealed knowledge level (Nickerson 1999; Nathan and Koedinger 2000; Nathan and Petrosino 2003).

The challenge of low codifiability and tacitness of knowledge was addressed by the explicit work phase for documenting each individual's knowledge at the beginning of the first workshop. As experts could see the mind maps of novices, they realized how much or little their colleagues knew about the work process structure. Reactions of experienced participants to their colleagues' work process drafts ranged from surprise at how little they knew about the process - "I thought this would be basic knowledge, but it seemed unfamiliar to them"[1] - to wondering how much information the inexperienced members could contribute. "My team partner said he never had to complete the work task himself. It was amazing how many steps of the work process he got right."

10.5.1.2 Experts' challenge to explicate their own knowledge

The second challenge that became evident on the experts' side was their struggle to retrieve and explicate their own knowledge and provide it to the group. Individual work process documentations of experts were, on average, more elaborate and more detailed than those of novices. However, for some of the experts it turned out to be very difficult to get started with a written documentation of their knowledge. They reported that they were not used to talking or writing about the manual work they were doing in their daily practice. As one participant noted, "It is difficult to remember all the work phases if you are not on site and really working. I might forget steps that I would usually do automatically." Although most of the experts

[1] All direct participant quotes are translated literally from their original language. However, they are marked with " " to distinguish them from summaries of participants quotes.

had executed their work processes various times, they became insecure on the right set and order of steps when asked to write it down from memory.

One potential explanation for this challenge may lie in the mastery level of “unconscious competence” that many of the experts possessed. Unconscious competence is the state of mastery where people “execute the skills and knowledge in their domain so automatically and instinctively that they are no longer consciously aware of what they know or do” (Ambrose et al. 2010). This kind of unconsciousness evolves because experts develop efficient ways of organizing their large base of knowledge, recognize patterns based on their experience and are able to apply shortcuts, of which novices would, as yet, not be aware. Also, due to their extensive practice in the specific work field, experts execute some activities automatically, whereas novices need to think about them explicitly and in detail. These activities might shift into unconscious competence, out of the expert’s attention and be difficult to put into words when documenting a work process. Furthermore, Hu (2005) submits that different generations of employees may diverge on their perceptions about what knowledge deserves to be retained. Thus, certain knowledge may be evaluated by experts as unimportant to be transferred to, and reused by, the next generation, but which may be considered as crucial from the novices’ point of view.

Several means of addressing this challenge were applied in the described workshop process. First of all, during the role briefing at the beginning of the collaboration process: expert and novice roles were made clear to all participants. Thus, experts knew about their responsibility to retrieve and share their knowledge and were aware of the different mastery levels within their team.

Additionally, the tool supported question and answer technique in the second workshop fostered the retrieval of knowledge of which experts were not aware For each step of the work process identified in the first workshop, novices were requested to type the questions into the group support system that they needed to answer to be able to execute the task. In this phase, experts no longer had to rely on their own assumptions on whether or not the certain information was important for novices. The interaction between novices and experts was induced instead.

In this interaction phase, one expert who had only four work process steps in his initial draft - less than most of the inexperienced members of his group - reported that it was hard for him to decide which information was important enough to be documented and which was unnecessary for a newbie. Just like many other experts, he also found it difficult to explicate his tacit knowledge, as he was used to executing the work task, but not to talking or writing about it. For this particular expert – as he explained – the questions of his less experienced colleague in the second session were enormously helpful to sort his knowledge and retrieve the parts that were relevant for generating good learning materials. The newbie's questions guided his explication effort more effectively. Experts in general valued this collaboration technique as a good pointer to issues they would not have documented, either because they were unconscious of this knowledge or did not see the need to include it in the training material. One participant noted that his inexperienced team partner made him aware of how detailed several steps of the work process really were. Another said that he found it helpful to document the questions and answers immediately in the group support system (instead of discussing them orally), as he "was forced to think about a good way to express the activities [he was] very familiar with, but never had to put into words."

Thus, the expert-novice question and answer interaction was considered to be helpful for the experts to explicate their knowledge in three different ways. First, by guiding them in order to decide on the specific knowledge and the level that was important for inexperienced colleagues to learn to execute the work process. Second, the question-answer interaction helped them to find a suitable level of detail and the right words that were understandable for novices, as novices would continue asking whether some answers were insufficient. Third, the questions coming from novices pointed experts to certain aspects of the steps or sub steps in the work process that fell into their unconscious competence and they would not have taken into consideration on their own.

10.5.1.3 Novices' challenge to identify their own potential contribution to the collaboration process

Novices also had to deal with several challenges. First, they mentioned insecurities about their level of expertise. One novice said at the opening round of the first workshop: "I don't really know why I was invited here. I hardly know anything about the topic, but I am curious what the experts will teach us." In the beginning of the first workshop, many novices were very shy and passive, as they were not aware of their potential contribution to the group work. They were all familiar with classical teaching formats and mainly expected input from their experienced peers. Every time they had to assess their experience and the level of knowledge on the work process, many novices expressed insecurities: they wondered if their prior knowledge would be enough to contribute anything valuable to the group. The few who had not executed the specific work task before even expressed that they had no complete or clear picture on the work task itself and of what was meant by the task definition as it was communicated to them. One novice said after the second workshop that although he still had no detailed knowledge of the work process, he found it much easier to interact with his team partner, once he had understood the overall work process structure and seen some pictures taken from the work process execution in practice.

The insecurities faced by novices can be described as a state of unconscious incompetence (Ambrose et al. 2010). Unconscious incompetence refers to an early state of learning in a field, where the learner lacks the basic structure and language on the topic to be aware of his own learning needs. In the case at hand, it was the novices who did not have a rough mental model of the work process and lacked a reference base for grounding continuative questions and adding new information. In cases where novices had no prior knowledge on the work process at all, cognitive proximity might have been too large to benefit immediately from experts' knowledge (Boschma 2005). Only if novices had a basic understanding, were they able to relate new information on the work process to it. In line with Harvey's (2012) notion, participants seemed to have been confronted with source-recipient approaches to knowledge transfer in their prior work that were still prevalent in research and corporate practice, rather than mutual exchange.

In the workshop process, this challenge is addressed by continuous, iterative interaction. The initial individual documentation phase helps novices to discover deficits of their specific knowledge as they try to document their own state of present knowledge. The series of workshops progress from finding an overall structure of the work process to adding more and more detail, context and visualizations. As such, novices are supported in developing an increasingly elaborated mental model of the task step-by-step, starting with the structure of the work process as a reference frame to sort new information.

Throughout the collaborative interaction, we found remarkable evidence of bridging barriers between experts and novices: namely, despite their lack of experience, inexperienced participants were surprised at how much they could contribute to the discussion. Reasons for this perception included the individual work and pairwise interaction in many of the collaborative work phases, the question and answer model, as well as the importance of the complementary IT skills in which they were better versed than were the older task experts. Due to the pairwise mode and the initial individual work phase, novices were encouraged to think about their own understanding of the work process. In many cases it seemed that they knew more about it than they were aware of. Further, they quickly noticed that their team partner could produce learning dialogues of high quality in the following question and answer chat activity with their thoughtful questions. If there had only been collaborative development in the whole team of six, experts might have interacted mainly with each other, and the inexperienced members might not have gained this knowledge. One-on-one interaction in the first collaborative phase with an expert urged novices to participate. Unlike in larger groups, freeriding was impossible. Additionally novices gained self-assurance for the later phases.

Another mechanism to bridge barriers between experts and novices was the use of a group support system for developing the learning dialogues in pairs of one expert and one novice each. Both observing researchers noted that in most teams, novice team members took more proactive roles in the computer supported phase of the workshop. Under these conditions, the information technology support was able to even out differences in expertise within the team by giving everyone the opportunity to type individually. Individually written contributions were documented and saved before any discussion could potentially eliminate contributions by apparently less experienced (or less extroverted, which correlated in many cases) team members. Computer literacy became a complementary qualification in which some participants had expertise, even though not necessarily being experts in the core work task.

10.5.1.4 Differences in information and meaning hinder expert-novice collaboration

When given the task of developing a process structure of the work process based on the individual drafts, many pairs struggled to get started. In early stages of experience-diverse collaboration, the different levels of information on the work process sequence as well as differences in meaning due to higher or lower familiarity with the company-specific language were the main issues (Kolfschoten et al. 2009). The former became evident in the novices' focus on questions on the different steps of work process, e.g., "What is...?", "Where do I find...?", "Whom should I contact in case...?" Differences in meaning emerged especially concerning company specific use of technical terms and acronyms. The researchers documented several cases of clarification of the meaning of terms in their field notes. Some participants expressed that it was difficult for them to distinguish which information was relevant for the work process documentation. In particular, main insecurities arose considering the issues on what knowledge was to be documented within the scope of the process or which was irrelevant. For example, one team was hindered by the decision, whether the tool setup needed to be described in the learning material and whether side processes executed by other departments deserved description or not. Furthermore, due to their very diverse own state of knowledge, expert-novice pairs diverged on the level of detail and abstraction that the documentation should have.

The initial issues to capture the scope of the work process collaboratively can partly be explained by the low demonstrability of the relevant knowledge. Knowledge demonstrability refers to "the extent that the merits of knowledge are recognizable" (Kane 2010). If knowledge is high in demonstrability, its merits are easily recognized by potential receivers. Higher demonstrability decreases cognitive processing load, requiring less inferences and less thorough consideration of knowledge to recognize its merits. In combination with their own unconscious incompetence, in the situation at hand, the tacit knowledge of experts is low in demonstrability for novices. They do not know a priori which information will help them to master the unfamiliar work process. Likewise, experts do not know which information is of value to the novices within their team (Hu 2005). Thus, it can happen that the relevant knowledge would not be taken into consideration, as on the one hand, experts might underestimate its importance and not explicate it proactively; on the other hand, novices might not request it, as they lacked the reference frame to understand its existence and value.

Clarification issues were solved while interacting with the individual and pairwise documentations that served as boundary objects (Koskinen and Mäkinen 2009), supporting the actors in clarifying wording issues and making clear the team members' elaborateness of understanding on the work process. In the first workshop, many of the general gaps in understanding between experienced and inexperienced partners were detected during the comparison of the individual work process documentations. Terms that were used orally were rarely questioned by inexperienced participants. We can interpret this as an indication of the need for individual written explication, especially if participants are unfamiliar with the work process and organizational language used.

Figure 4 shows an example of two drafts of initial work process created individually in the left picture: with the novice's draft (right side) being significantly shorter and less elaborated than the expert's draft (left side). The right picture shows the combined draft of expert and novice that contains work process steps from both of them after the merging activity.

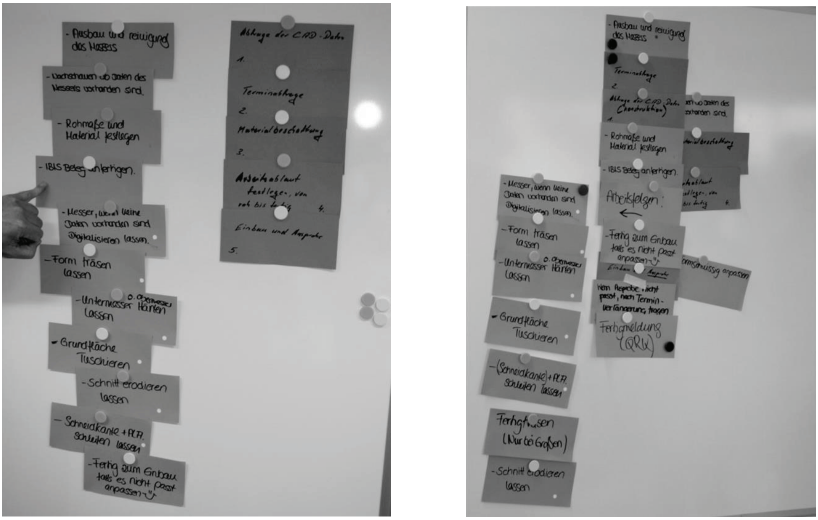

Figure 4. Exemplary work process structure draft of experienced (left side of first picture) and inexperienced team member (right side of first picture) and their combined pairwise draft (second picture).
Source: Own representation

10.5.2 Challenges in Collaborations among Experts

When we analyzed the interaction of experts throughout the workshop process, it became apparent that it differed significantly from the interaction of experts with novices. As expected, experts were mostly a lot faster in grasping each other's contributions and understanding each other's expressed views. In general, the discussion between experts was more diverse if participants came from different shifts or work groups. Within their shifts and work groups, experts appeared to be already exchanging information on a regular basis or even asking for the opinion of others when a complex problem arose. Their challenges in the workshops were mostly related to revealing differences in details of their complex mental models that they were not aware of, as well as negotiating consensus if their established routines diverged.

10.5.2.1 Challenge to reveal complex individual mental models

When experts synchronized their work process structures from the pairwise phase, they went over the documentation much faster than did their inexperienced peers. While talking to each other, two experts often focused their clarification discussion on selected wording issues. It became clear that all of the experts held their own detailed mental models for the steps of the work process and found it easy to understand and assess the input from their peers.

These observations are in line with prior research on Shared Understanding (Mathieu et al. 2000; Cannon-Bowers and Salas 2001; Kleinsmann et al. 2010; Mohammed et al. 2010; Bittner and Leimeister 2014) and cognitive proximity (Boschma 2005; Harvey 2012). Due to their longtime association with the same organization and their similar experiences with the work process, experts simultaneously held mental models that were very elaborate and very similar. Even if the mental models differed in some points (e.g., as there were several equally suitable ways to complete a certain step of the work process) and experts had developed different personal routines throughout the years, the overlap was usually large enough to understand each other immediately in a mutual way. However, the strong routine of experts with the work process also led to challenges that became apparent in the workshop series. For example, experts sometimes quickly went over a certain step in the work process described by a short title. At that point, they signaled that the step was completely clear to them and they agreed on its content. Later on, when it came to formulating the concrete learning dialogue, discussions arose on what the step really meant and what the description should include. In some cases, experts turned out to have very different ways of executing a certain step in the work process, which would not have become apparent if they would not have needed to converge on a detailed description.

We thus found several strategies within the workshop process that favored the detection of differences in details of the mental models among experts. First, some participants mentioned that it was valuable to them to be forced to write down (in the first workshop) or type their information (in the second workshop) rather than just discussing it orally. In such a way, experts were encouraged to ponder their wording, and differences in handling became more visible and present to the others.

As experts were not often aware initially that their way of executing the work process was not the only established one, this form of explication helped to point experts to these issues.

The synchronization of mental models among experts was supported by the visual representation of the work process structure from each individual. In the group discussion, experts used it to detect differences in the framing of the steps in the work process and their order. Later on, when expert-novice pairs had developed question-and-answer-dialogues for each step of the work process, the textual descriptions and accompanying pictures served as reference points for clarification. A few experts even made use of tangible material they found in the meeting lab, such as a box, pens and sticky tape in order to illustrate the minor differences in the approach that they wanted to show their peers.

In general, the more detailed and the richer the information was represented, the more differences in understanding could be revealed among experts. While novices predominantly needed clarification on an abstract or structural level, experts showed differences on a more specific level. It can thus be summed up that among experts, detailed documentation and lifelike visualization seem to be of special importance to foster mutual understanding.

10.5.2.2 Challenge to negotiate Shared Understanding

While mutual understanding was relatively easy to reach among experts due to the high level of initial Shared Understanding, negotiation of a shared perspective took more effort in the expert-expert interaction. Most experts produced detailed representations of the work process in the first phase, representing their advanced mental models on the work process that evolved over years of continuous practice. When asked to converge on a joint standard sequence of the work process, discussions arose between different experts in all teams where no prior standard of the work process existed or where the sequence was not logically predetermined (e.g., if a certain machine could only be assembled in a certain order of steps by design).

When structuring the work process in the first individual phase and looking at their peers' process structures afterwards, it quickly became clear that experienced participants could very rapidly understand their peer's structure, even if it diverged in some detail. In most cases, the comprehension of cause-and-effect chains was very similar among experts. Only in a few situations were mental models challenged, e.g., when one participant could successfully argue why a certain step or sequence of the work process had turned out to be more efficient or less error-prone in his personal experience. When two experts had expressed different approaches to a certain step of the work process (e.g., a different order of checking potential causes for a production error), it was sometimes not possible for the group to easily determine which strategy was superior. For example, if one team could not really decide which one of two alternative orders of two steps in the work process was superior, the alternatives were often defended by arguments such as, “I don’t really know why, but I have always been doing it this way and it worked fine” or by preferences of the more secure or faster way.

Mostly, both ways had been used by one of the experts on a regular basis and had proven to be useful. Sometimes, the group could come to the conclusion that under certain conditions one strategy might be the better one to use than another. For example, if one way was faster, but the other one was more accurate, the group would decide to recommend the faster way for situations when the error would cause a downtime of the production process, whereas the more accurate one would be used if a backup tool was available to replace the tool in repair. Most differences and conflicts arising in these teams were related to differing taste or personal goals (Kolfschoten et al. 2009).

The fact that experts spent more effort on negotiating consensus than on clarification might be explained by the different sources of disagreement that Kolfschoten et al. (2009) identify. As experts familiar with the work process generally hold more advanced and more similar mental models and information than do novices, the disagreements in their interaction would more strongly result from differences in taste and goals. From their longtime work experience, they may have developed a fixed perspective on how something should be done and might have lost flexibility to adopt alternative approaches. Thus, in expert-expert interaction, collaboration support should focus on getting from mutual understanding to Shared Understanding.

In the case study situation at hand, this challenge was addressed by documenting decisions, applying negotiation techniques and separating viewpoints from actors. First, negotiation was supported by using a modified ReviewReflect collaboration technique to extract conflicting aspects from the documents on the structure of the work process by marking them in order to discuss them separately and finding a consensus for each of them (see Bittner and Leimeister (2014) for a detailed description of the technique). Participants were thus guided with the purpose to identify all conflicts systematically and not to forget to solve any aspect.

Second, every aspect that the group agreed on was immediately documented by the participants themselves on paper cards or within the group support system. In line with the advantages of indirect knowledge transfer where previously non-codified knowledge is codified (Guechtouli et al. 2013), already solved problems were visible to the participants at all points in time. Some participants noted that they found this helpful, as they "did not get into the trap of discussing the same issues again and again, as it often happens in a group work" or that "it was good to keep track of the issues we still had to define a standard for in the learning material." The continuous work on shared material allowed the experts to keep track of the current state of their consensus.

Third, the use of the group support system turned out to be advantageous in terms of fostering consideration of alternative perspectives independent of their contributors. When ideas on a certain step of the work process had been entered into the group support system and were visible to all team members on their computer screens, they discussed these ideas in a relatively open and unbiased manner. For these aspects, it was of minor importance who contributed which viewpoint. What was relevant was that the group discussed them to find a consensus to which they could all agree. This perception was important to the participants, as some issues were critical because of the discussion that challenged the way an expert had been executing a certain task for years. Through the group support system, participants had the general impression that they compared alternative approaches rather than judging whether some of them had worked better or worse in the past.

10.6 Conclusions and Future Work

Taking all collected data into consideration, we found indication of interesting relationships between collaborative interaction of work groups with diverse experience, their development of Shared Understanding and knowledge transfer. We identified several challenges and clarification mechanisms in the case study setting that depended on the phase of collaboration, the type of paring (expert-novice or expert-expert) and the use of different collaboration supporting techniques and tools. Table 3 gives an overview of the findings and potential implications for comparable knowledge management challenges in heterogeneous groups.

Type of interaction	Challenge	Theoretical background	Solution ideas for collaboration design
expert-expert	Elaborate individual mental models fostered clarification phase: danger to overlook differences in details	High level of initial Shared Understanding due to relative homogeneity in background and experience; unconscious competence	Visual representations of individual and team mental models point out differences and conflicts. Detailed textual descriptions of all information serve as boundary objects and reference points, tangible prototypes to clarify details in experience knowledge
	Negotiation of consensus difficult and time-consuming	Prevalent differences in personal goals and taste due to elaborate individual mental models	Negotiation techniques; documenting decisions; separate viewpoints from actors
expert-novice	Experts struggle to assess novice knowledge level	Low codifiability of knowledge; high tacitness, expert blind spot	Phase for initial explication of individual knowledge
	Experts struggle to retrieve and explicate own knowledge	Unconscious competence mastery level	Initial role briefing; tool supported Q&A technique to find suitable level of detail and focus and point to unconscious knowledge
	Insecurities of novices about their own potential to contribute	Unconscious incompetence mastery level	Phase for initial explication of individual knowledge; iterative one-on-one interaction with experts, progress from overall structure of the work process to specific content; use of technological expertise of novices in tool supported collaboration to even out imbalances
	Scarce initial individual work process draft of novices; novices questions mainly around factual knowledge	Prevalent differences in information between experts and novices; low demonstrability of experts knowledge	Individual initial work process documentation as boundary objects to reveal information gaps of novices, Q&A technique for exchanging information
	Clarification issues of company specific terms	Prevalent differences in meaning between experts and novices	Written documentation to reveal issues in interpretation of terms

Table 3. Overview of findings
Source: Own representation

In the case study at hand, it became clear that collaboration of experience diverse teams can provide benefits for both experienced and inexperienced participants as well as for their organization to profit from high quality group products if the required conditions are met.

Therefore, we recommend that the implications listed in Table 3 should be taken into consideration by designers of collaborative work practices for heterogeneous work. We find initial indication that expert-novice interaction should be supported, especially in situations where gaps of information and meaning are to be bridged. Furthermore, novices can contribute by helping experts in explicating their knowledge and finding an understandable representation of manageable complexity. If enough effort is put into the initial phase of building a sufficiently elaborated shared mental model of the work process structure, novices may be enabled to contribute questions and knowledge on a substantially higher level of complexity. Complementary expert-expert interaction can furthermore contribute to more detailed descriptions as well as to the definition of standards in cases of conflicting personal goals and taste. In the case at hand, the combination of both forms of interaction led to reduced prejudices, increased communication and high identification of the pilot participants with the resulting learning materials.

10.6.1 Limitations and Future Work

Attributed to the exploratory nature of case study research, insights are in the first place related to the specific setting at hand. The study's goal was to develop a rich picture of the interaction modes and knowledge transfer in this specific setting. We focused on expert-expert and expert-novice interactions, and their relations with techniques and tools for knowledge integration support in experience-diverse workshops. Due to the complex nature and great variety of social interaction and knowledge management challenges, different projects would pose modified challenges and different team staffing situations might induce other interaction modes. This study should thus be interpreted as a valuable starting point for further investigations.

In line with the limitations of the current work, future research should use our results to analyze comparable cases of heterogeneous group work and knowledge integration, investigating whether similar collaborative patterns occur in other settings and if the challenges and approaches to solve them are recurring. These efforts and cross-case comparisons could advance research on knowledge transfer in heterogeneous teams and fertilize ongoing research attempts to develop design theory for knowledge transfer practices.

10.6.2 Conclusion

This paper presents the results of a real world case study on knowledge transfer in age- and experience diverse work groups in an automotive company. Analysis of the data from workshop series on knowledge sharing that represent a one year pilot project provides indication of recurring interaction mechanisms, challenges and solution approaches towards knowledge transfer among experts and between experts and novices. These insights contribute to knowledge transfer research by pointing out potential determinants of knowledge sharing to be used in analyzing comparable settings and prospectively developing design theory for collaboration practices to support knowledge transfer in heterogeneous groups. It furthermore provides practitioners dealing with heterogeneous work groups with a set of issues and potential solutions to be considered when they design processes to support learning and knowledge integration.

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11 Wissenstransfer in altersgemischten Teams – Das TANDEM-Workshopkonzept zur Weitergabe von Erfahrungswissen und Entwicklung von gemeinsamem Verständnis

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Abstract: Die Sicherung und Weitergabe von Erfahrungswissen über Mitarbeitergenerationen hinweg stellt vor dem Hintergrund des demografischen Wandels eine zentrale Herausforderung im Wissensmanagement von Organisationen dar. Hierfür mangelt es bislang an systematischen Lösungskonzepten. Die vorliegende Fallstudie beschreibt das TANDEM-Workshopkonzept zur Weitergabe von Erfahrungswissen in erfahrungsgemischten Arbeitsgruppen. Collaboration Engineering wird als Ansatz zur Entwicklung wiederholbarer, hochwertiger Zusammenarbeitsprozesse eingesetzt, um ein dreitägiges Workshopkonzept zu konzipieren und pilotieren. Dieser Beitrag präsentiert das validierte Prozessdesign sowie Erkenntnisse aus dem praktischen Einsatz im Wissenstransfer von altersdiversen Facharbeitern in einem Automobilunternehmen. Er gibt Entscheidern in Unternehmen und Entwicklern von Wissensmanagementsystemen Werkzeuge und Empfehlungen an die Hand, wie Wissenstransfer und gemeinsames Verständnis zwischen Experten und Novizen erfolgreich unterstützt werden kann.

Keywords: Collaboration Engineering, Shared Understanding, thinkLet, Wissensmanagement, MindMerger.

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11.1 Motivation und Zielsetzung

Wissen ist in einem sich immer schneller wandelnden Umfeld zur zentralen erfolgskritischen Ressource für viele Organisationen geworden (Sawhney and Prandelli 2000; Madhoushi and Sadati 2010). Das notwendige Wissen für Arbeitsprozesse und Innovationen wird durch technologischen Fortschritt immer vielfältiger und komplexer (DeLong 2004). Oft hängt die erfolgreiche Durchführung technologiegetriebener Arbeitsprozesse maßgeblich von der Expertise einzelner Wissensträger ab. Verlassen diese Personen das Unternehmen oder stehen aus anderen Gründen nicht zur Verfügung, sind diese Prozesse gefährdet. Nur wenn es gelingt, Wissen in der Organisation zu bewahren, Wissensaustausch zwischen Mitarbeitern zu unterstützen, und systematisch neues Wissen zu generieren, bleiben Organisationen innovations- und wettbewerbsfähig.

Andererseits hat sich die demographische Struktur der Belegschaft in vielen Branchen stark verändert und wird dies in den kommenden Jahrzehnten in zunehmendem Maße weiter tun. Die erwerbstätige Bevölkerung in vielen Industrienationen wird älter und kleiner, wenn sich die Generation der „Babyboomer“ dem Rentenalter nähert. Die viel kleinere Gruppe der „Generation Y“ muss innerhalb kurzer Zeit befähigt werden, Ihre Expertise und Aufgaben zu übernehmen. So ist beispielsweise in Deutschland zwischen 2000 und 2025 ein Rückgang der erwerbstätigen Bevölkerung um 20% zu erwarten. Demgegenüber steht ein erwartetes Wachstum des Rentneranteils um 50% (DeLong 2004). Zweifelsohne wird somit in den nächsten Jahren eine große Welle an langjährigen Experten aus dem Arbeitsleben ausscheiden. Unternehmen stehen vor der enormen Herausforderung, den Abfluss von Erfahrungswissen bei Renteneintritt oder beim Verlust von Experten aus anderen Gründen zu verhindern. Erwiesenermaßen ist es kaum möglich, erfahrene durch neue Mitarbeiter zu ersetzen, ohne dass das Erfahrungslevel der Arbeitsgruppe massiv darunter leidet. Lebenslange Erfahrung kann kaum innerhalb weniger Ausbildungsjahre erlernt und nur schwer von Mensch zu Mensch weitergegeben werden (Sporket 2011). Ungeteiltes Wissen kann zum Hindernis in Arbeitsgruppen werden und stellt eine wichtige Herausforderung für die Gestaltung der Zusammenarbeit in diesen Gruppen dar (Piirainen et al. 2012). In Organisationen mit heterogenen Belegschaften müssen Wissensmanagementprozesse etabliert werden, um junge, weniger erfahrene Mitarbeiter frühzeitig darauf vorzubereiten, komplexe Arbeitsprozesse selbständig durchzuführen und das Expertenwissen ihrer erfahrenen Kollegen zu übernehmen. Hierfür müssen Unternehmen verstehen, wie Wissenstransfer funktioniert und welche Faktoren Wissensaustauch und -integration beeinflussen. Bisher herrscht jedoch in Forschung und Praxis ein Mangel an Wissen, wie die Wissenslücke zwischen Experten und Novizen in heterogenen Arbeitsgruppen systematisch überbrückt werden kann. Methoden zum kollaborativen Lernen (Xin and Xiaoying 2010; Gerstenmaier and Mandl 2011) und zur Entwicklung gemeinsamen Verständnisses (Bittner and Leimeister 2014) gewinnen in diesem Kontext an Bedeutung.

Dieser Beitrag nimmt sich dieser Forschungslücke an, indem er einen Lösungsvorschlag in Form eines Workshopprozessdesigns zur Unterstützung des Wissenstransfers zwischen Experten und Novizen vorstellt. In einer realweltlichen Fallstudie wurde der Workshopprozess mit 48 Facharbeitern unterschiedlichen Alters in einem Automobilkonzern pilotiert. Das Prozessdesign wird in diesem Beitrag detailliert dokumentiert, damit es auf andere Organisationen übertragen und dort mit wiederkehrendem Erfolg zur Verbesserung des Wissenstransfers in Arbeitsgruppen eingesetzt werden kann. Zudem leistet dieser Artikel einen Beitrag zum Verständnis von Wissenstransferprozessen in der Interaktion von Experten und Novizen. Wir untersuchen explorativ Faktoren, die im Anwendungsfall den Wissenstransfer fördern oder behindern und ziehen Schlüsse für das Design von Wissensmanagementprozessen.

Der Rest dieser Fallstudie ist wie folgt aufgebaut. Zunächst wird die Fallauswahl und das Fallstudiendesign sowie der Fall und die Teilnehmer beschrieben. Außerdem geben wir einen Überblick über die Datensammlung und –analyse. Die Ergebnisse der Fallanalyse und Erkenntnisse zur Beantwortung der forschungsleitenden Fragen werden präsentiert. Der Beitrag schließt mit Implikationen für die betriebliche Anwendung und Anschlussforschung im Wissensmanagement. Um die Möglichkeit zu erhalten, in dieser Studie offen für unerwartete Erkenntnisse zu bleiben, definieren wir vier relativ allgemeine Leitfragen für die folgenden Untersuchungen:

Welche Situationen, in denen es an Shared Understanding mangelt, entstehen in den neu gebildeten heterogenen Gruppen im Rahmen der Fallstudie? Wie werden diese erkannt? Wie werde sie gelöst?

Welche Erfahrungen konnten beim Pilotprojekt gesammelt werden für die fortlaufende Umsetzung und weitere Wissensintegration-Projekte?

11.2 Fallauswahl und -beschreibung

11.2.1 Fallauswahl

Der Fall für diese Studie wurde ausgewählt, da er für die Herausforderungen im Wissensmanagement repräsentativ ist, die viele Unternehmen im demografischen Wandel betreffen. Das Durchschnittsalter der Arbeitnehmer in der untersuchten Abteilung des betrachteten Unternehmens ist in den letzten Jahrzehnten wesentlich angestiegen. Ein erheblicher Anteil erfahrener Mitarbeiter wird das Unternehmen in den nächsten fünf Jahren verlassen. Neue, noch unerfahrene Arbeitskräfte sind da, um die Nachfolge anzutreten, haben jedoch im Arbeitsalltag zu wenig Zeit, sich notwendiges Anwendungswissen von erfahrenen Kollegen anzueignen. Durch Schwankungen in der Einstellungspolitik der vergangenen Jahrzehnte ist die Abteilung durch eine Alterslücke der Arbeitskräfte zwischen 30 und 40 Jahren geprägt. Erfahrene Mitarbeiter, die ein großes implizites Anwendungswissen für komplexe Arbeitsprozesse sowie organisationsspezifisches Hintergrundwissen aufweisen, sollten in der letzten Phase ihrer beruflichen Laufbahn mit jungen Mitarbeitern, die noch wenig Erfahrung in diesem Bereich haben, zusammenarbeiten und eine gemeinsame Wissensbasis aufbauen. Im, für diese Fallstudie begleiteten, Pilotprojekt bestand die Möglichkeit, die Interaktion sowohl zwischen erfahrenen und neuen Mitarbeitern als auch zwischen erfahrenen Mitarbeitern zu untersuchen. Demnach stellt diese Situation einen geeigneten Fall für die Untersuchung der forschungsleitenden Fragen zur Wissensintegration in heterogenen Teams dar.

Darüber hinaus haben wir diese Fallstudie wegen der Zugänglichkeit der Daten ausgewählt. Das Untersuchungsteam konnte das komplette Projekt begleiten und Daten zu unterschiedlichen Themen und aus verschiedenen Quellen sammeln.

11.2.2 Fallbeschreibung

Diese Fallstudie bezieht sich auf ein Wissensmanagement-Projekt in einem großen Industrieunternehmen der Automobilbranche. Wie viele andere Firmen, steht auch dieses Unternehmen vor der Herausforderung, seine Mitarbeiter zu einem Wissenstransfer zu unterschiedlichen Themen anzuregen. Arbeitnehmer, die eine lange Zeit im Betrieb tätig sind, haben große Erfahrung und ein tiefes Verständnis für die Arbeitsabläufe. Gleichzeitig sind sie mit dem stets wachsenden Tempo technologischer Veränderungen in ihrem Arbeitsumfeld konfrontiert. Das Unternehmen läuft Gefahr, Kenntnisse und implizites Wissen der Mitarbeiter, die sich dem Rentenalter nähern, zu verlieren, wenn die erforderlichen Maßnahmen zur Unterstützung des Wissenstransfers zu den nachfolgenden Mitarbeitern nicht ergriffen werden. Andererseits bringen neue Arbeitnehmer die aktuellste technische Ausbildung mit und können innovative Lösungen in die bestehenden Arbeitsprozesse einbringen. Dennoch fehlen ihnen das spezifische Wissen und Erfahrung bei komplexen Aufgaben. Junge Mitarbeiter, die erst kürzlich ihre Berufsausbildung abgeschlossen haben und ältere Mitarbeiter, die mehr Erfahrung besitzen, sollen voneinander lernen, um das kritische Wissen vor dem Verschwinden aus der Organisation zu bewahren. Der demographische Wandel verstärkt diese Herausforderung, da sich eine große Anzahl an Experten dem Rentenalter nähert und nur wenige junge Facharbeiter qualifiziert sind, ihre Arbeitsplätze zu besetzen. Beide Gruppen (erfahrene und weniger erfahrene Arbeitnehmer) sollen die Potentiale gegenseitigen Lernens erkennen und zusammen arbeiten, damit die Arbeitsabläufe im Betrieb effizient verlaufen.

Das Projekt wurde in Werkzeugbau und Instandhaltung für komplexe Produktionsmaschinen durchgeführt. Die Pilotierung des Kollaborationsprozesses hatte zum Ziel, in einer Reihe von Workshops die Erfahrung verschiedener Werkzeugbauer zu integrieren. Die Facharbeiter wurden von einem erfahrenen Moderator durch den gesamten Prozess geführt, um Schulungsbausteine für ausgewählte Arbeitsabläufe in ihrem Arbeitsumfeld zu erarbeiten, Diese Schulungsmaterialien sollen unerfahrenen Mitarbeitern als Nachschlagewerk helfen, komplexe Arbeitsaufgaben selbständig auszuführen. Auf diese Weise steigert der Prozess den gegenseitigen Wissenstransfer und stellt sicher, dass das implizite Wissen unabhängig von einzelnen Individuen in der Organisation bewahrt wird.

11.2.3 Teilnehmerbeschreibung

Die Heterogenität der Gruppenmitglieder, die für das Projekt gewonnen wurden, zeigt sich in mehreren Dimension, z.B.: Alter, Geschlecht, Ausbildung, Arbeitserfahrung, Unternehmenszugehörigkeit. Jede Gruppe setzt sich aus jeweils dreit von ihren Führungskräften als erfahren klassifizierten Experten und drei unerfahrenen Novizen im Hinblick auf das als Gruppe zu dokumentierende Thema zusammen. Wie aus Tabelle 1 ersichtlich wird, haben 48 Facharbeiter an dem Projekt teilgenommen, fünf Frauen und 43 Männer. Das Durchschnittsalter von erfahrenen bzw. unerfahrenen Teilnehmern betrug jeweils 44.16 und 24.09 Jahre, dabei war der älteste Teilnehmer 57 und der jüngste 19 Jahre alt. Die gesamte

Arbeitserfahrung der Teilnehmer wies eine hohe Bandbreite von fünf Wochen bis zu 42 Jahren auf.

	Unerfahren	Erfahren	Gesamt
Geschlecht (Anzahl)			
Weiblich	4	1	5
Männlich	20	23	43
Gesamt	24	24	48
Alter (Jahre)			
Minimum	19	23	19
Durchschnitt	24,09	44,16	34,29
Maximum	35	57	57
Arbeitserfahrung (Jahre)			
Minimum	0.1	1	0,1
Durchschnitt	8,88	24,42	16,81
Maximum	17	42	42

Tabelle 1. Demographische Angaben der Teilnehmer

Quelle: Eigene Darstellung

11.3 Datenerhebung

Die Daten für die vorliegende Fallstudie wurden im Laufe von dreizehn Monaten in den Jahren 2012 und 2013 gesammelt. Insgesamt sind acht Teams mit jeweils sechs Arbeitsnehmern durch den Workshop-Prozess gegangen, um Schulungsbausteine zu erarbeiten. Die Erkenntnisse aus dem iterativen Vorgehen der Datenerhebung und Analyse haben zu einer Anpassung von Methoden der Datenerhebung während des Projektes geführt. Eine Liste mit Leitfragen für Feldnotizen wurde im September 2012 eingeführt, um die Aufmerksamkeit der wissenschaftlichen Beobachter auf kritische Ereignisse während der Gruppenzusammenarbeit zu lenken. Zusätzlich wurden die Teilnehmer der achten Gruppe einzeln interviewt, um die Daten, die in den anderen Gruppen gesammelt wurden, zu ergänzen und die ersten Erkenntnisse zu überprüfen. Abbildung 1 stellt eine Übersicht des zeitlichen Ablaufs der Datenerhebung dar.

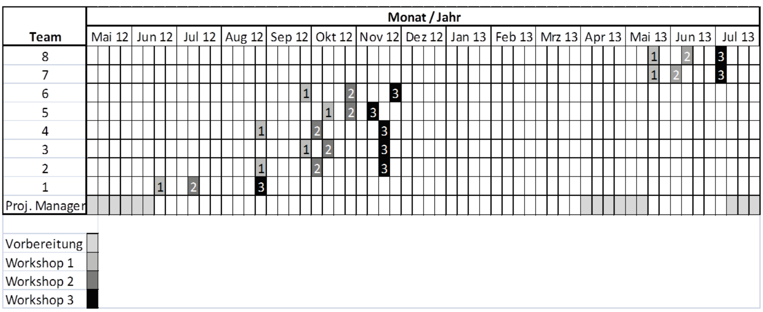


Abbildung 1. Datenerhebungszeitpunkte im Pilotprojekt

Quelle: Eigene Darstellung

Folgende Methoden der Datenerhebung wurden angewandt:

- Beobachtung: Zwei Forscher haben die Gruppenzusammenarbeit während der kompletten Workshopserie beobachtet und dabei Feldnotizen zu allen untersuchungsrelevanten Aspekten gesammelt. In den letzten vier Workshopreihen wurde das Sammeln von Feldnotizen durch offene Leitfragen unterstützt. Nach jedem Workshop haben die beiden Forscher ihre Beobachtungen besprochen und weitere Notizen ergänzt, die aus dieser Diskussion entstanden sind.
- Fragebogen: Zu Beginn und am Ende jedes Workshops mussten die Teilnehmer einen geschlossenen Fragebogen ausfüllen, der Informationen zu demographischen Daten, zur Selbsteinschätzung der Gruppe sowie zu dem geteilten Wissen und der Teamleistung umfasste.
- Feedback der Teilnehmer: Am Ende des dritten Workshops wurden die Teilnehmer gebeten, ein schriftliches Feedback zu drei verschiedenen Themen abzugeben: Erstens wurden sie nach Vorschlägen gefragt, wie man den Wissenstransfer und die Integration der Workshopergebnisse in ihr Arbeitsfeld verbessern kann, einschließlich der Nutzung der Schulungsbausteine, die sie gerade entworfen haben. Zweitens wurden sie gebeten, neue Erkenntnisse für ihre alltägliche Arbeitspraxis zu dokumentieren, die sie aus dem Workshop erlangt haben. In dieser Feedbackrunde wurden von den Arbeitskollegen übernommene Erfahrungen zu dem betrachteten Arbeitsprozess ebenso erfasst wie Potenziale zur Verbesserung des Arbeitsprozesses. Drittens haben die Teilnehmer Feedback zu den Workshops und dem Pilotprojekt gegeben.
- Dokumentation der Gruppenprodukte: Im Laufe der Workshopserie haben die Teilnehmer an individuellen und gemeinsamen, papierbasierten und digitalen Artefakten gearbeitet, die analysiert werden konnten, um den Prozess des Wissensaustauschs und die Entwicklung von Shared Understanding zu verfolgen. Die unterschiedlichen Zwischenstände der strukturierten Visualisierung der Arbeitsprozesse mit Hilfe von Karteikarten im ersten Workshop sowie die Dialoge und Feedbackkommentare, die die Teilnehmer im zweiten Workshop geschrieben haben, waren für uns von besonderem Interesse.

11.4 Validierung

Mit dem Ziel höhere Validität der Daten und Ergebnisse dieser Fallstudie zu erreichen, wurden unterschiedliche Messinstrumente eingesetzt, die Runeson und Höst (2009) vorschlagen. Erstens wurde die Strategie der Triangulation von Datenquellen, Beobachtern, Methoden der Datenerhebung und theoretischen Perspektiven angewendet. Ziel von Triangulation ist es, ein möglichst breites Bild einer komplexen Situation zu liefern und dabei die Einschränkungen einzelner qualitativer Datenquellen auszugleichen. Demzufolge wurden Daten aus diversen Quellen gesammelt, z. B. unmittelbar von allen Teilnehmern, durch die Beobachtung zweier Forscher sowie aus den Dokumentationen, die im Laufe der Workshops durch Teilnehmer entstanden sind. Alle gesammelten Daten und deren Interpretation wurden von einem zweiten Forscher überprüft, der ebenso bei jedem Workshop anwesend war. Die Dateninterpretation und Schlussfolgerungen, die in diesem Bericht präsentiert werden, wurden ebenso von diesem Forscher geprüft. Unterschiedliche qualitative (Interviews, Beobachtungen, Feldnotizen und das Feedback der Teilnehmer) und quantitative (demographische Daten der Teilnehmer und Fragebogen zur Selbsteinschätzung) Messmethoden wurden verbunden. Feedback der Teilnehmer wurde, für alle anderen Workshopteilnehmer sichtbar, über das verwendete Gruppenunterstützungssystem gesammelt, kontroverse Ideen wurden diskutiert und von der Gruppe kommentiert. Somit fand eine Validierung des Teilnehmerfeedbacks direkt durch die anderen Gruppenmitglieder statt.

11.5 Beschreibung der Workshopserie

Jedes 6er-Team bekommt zu Beginn des ersten Workshops ein Thema zu einem Arbeitsprozess, mit dem sie gut vertraut sind und der zu ihrem Fachgebiet gehört. Es werden komplexe Themen bearbeitet, die bei der Einarbeitung neuer Mitarbeiter in der Regel viele Ressourcen beanspruchen. Die Zielsetzung für die Teams liegt darin, die gewählten Arbeitsprozesse in Form von Schulungsbausteinen zu dokumentieren, die möglichst gut die notwendigen Kenntnisse und Fähigkeiten vermitteln. Die Teilnehmer werden bei Erstellung der Schulungsmaterialien in einer dreitägigen Workshopserie begleitet. Das heißt, dass jedes Team je einen Kick-off-, Ausarbeitungs- und Finalisierungsworkshop in Abständen von jeweils ca. 2 bis 4 Wochen zu durchläuft.

Die drei Workshops (Kickoff-, Ausarbeitungs- und Finalisierungsworkshop) werden im Weiteren ausführlich beschrieben.

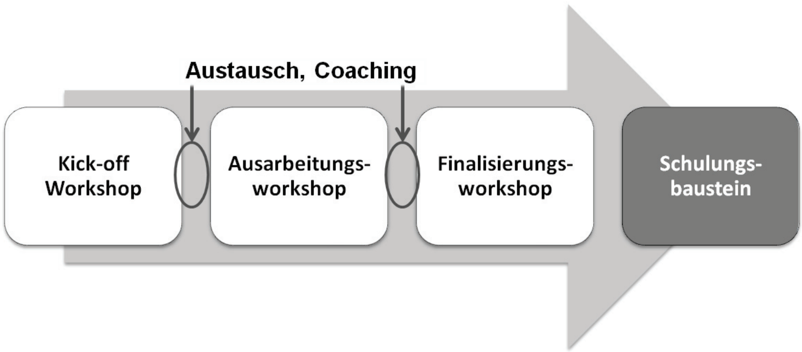


Abbildung 2. Abfolge der Workshops
Quelle: Eigene Darstellung

11.5.1 Kickoffworkshop

Am Anfang des Workshops stellen sich alle Beteiligten vor. Die Teilnehmer bekommen eine kurze Einführung zum gesamten Projekt, seiner Zielsetzung und dem angestrebten Nutzen für die Teilnehmer. Ein Überblick über die Arbeitsphasen zur Erreichung des Gruppenzieles wird gegeben.

Der erste Workshop hat zum Ziel, eine Struktur für einen Schulungsbaustein zu entwickeln und festzuhalten, was man bei jedem Arbeitsschritt in dem definierten Arbeitsprozess wissen und können muss. Der Ablauf des Kickoffworkshops hat folgende Struktur, die aus vier Phasen besteht:

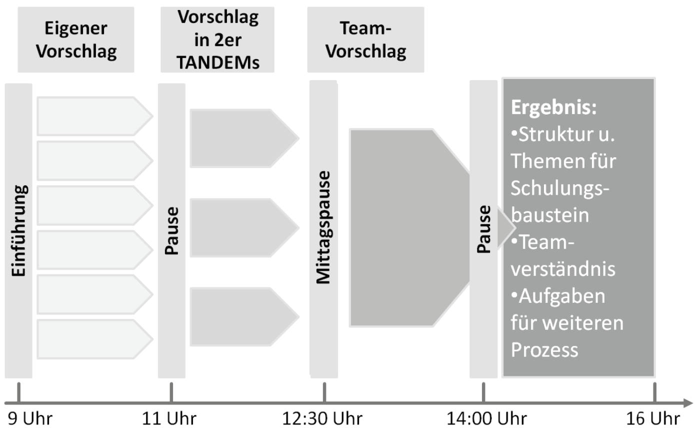


Abbildung 3. Aufbau der ersten Workshops
Quelle: Eigene Darstellung

11.5.1.1 Erste Phase

In der ersten Phase des Workshops sollen die Teilnehmer den Arbeitsverlauf notieren. Diesen Vorschlag soll jeder alleine erstellen, ohne die Schritte mit den Teampartnern zu diskutieren oder die Reihenfolge zu besprechen. Die Teilnehmer sollen die Arbeitsschritte auf Karteikärtchen notieren (eine Karteikarte pro Arbeitsschritt). Jeder erhält die Kärtchen in einer bestimmten Farbe (blau, weiß, rot, gelb, grün und orange), die bis zum Ende des Workshops beibehalten wird, damit über den Prozess hinweg erkennbar ist, wer welchen Beitrag geleistet hat.

Abbildung 4. Kärtchen für den Vorschlag
Quelle: Eigene Darstellung

Jedes Kärtchen soll eine Überschrift mit dem Thema (z.B. Messbericht, Werkzeug, Maschine X etc.) enthalten, die einem einzelnen Arbeitsschritt im Arbeitsprozess entspricht. Des Weiteren soll das Kärtchen eine stichpunktartige Beschreibung der Teilschritte erfassen, die unter dem Arbeitsschritt erledigt werden sollen (z.B. lesen, Daten eingeben, von Abteilung XY überprüfen lassen, etc.). Anschließend sollen alle Kärtchen chronologisch geordnet werden.

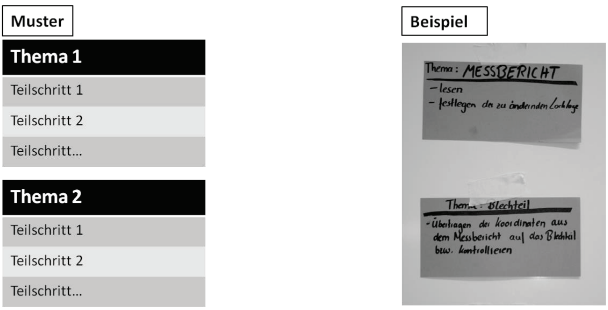


Abbildung 5. Muster und Beispiel zum Arbeitsauftrag
Quelle: Eigene Darstellung

Die individuellen Beschreibungen der Arbeitsabläufe sind im Ergebnis oft sehr unterschiedlich, obwohl alle Teilnehmer einer Gruppe denselben Arbeitsprozess beschreiben. Die Beschreibung des Arbeitsprozesses fällt nicht allen leicht. Der beteiligte Forscher, der den Workshopprozess moderiert, unterstützt die Teilnehmer, die Probleme haben, den Arbeitsprozess zu strukturieren oder aufzuschreiben. Er spricht passive Teilnehmer persönlich an, stellt Nachfragen zu bereits geschriebenen Karten, animiert Teilnehmer, sich in die Durchführung des Arbeitsprozesses hineinzuversetzen oder schreibt selbst Gedanken von Teilnehmern nieder, die im Gespräch geäußert werden.

11.5.1.2 Zweite Phase

In der zweiten Phase des Workshops sollen jeweils zwei Teilnehmer ihre Vorschläge in einem gemeinsamen Entwurf des Arbeitsprozesses zusammenführen. Die Zweierteams werden so zusammengestellt, dass jedes einen erfahrenen und einen unerfahrenen Teilnehmer enthält. Durch die Zusammenarbeit von Experten und Novizen soll ein kreativerer, vollständigerer Vorschlag entstehen.

Um die Aufgabe unabhängig von den Sichtweisen der anderen Zweierteams zu erfüllen, werden die drei Experten-Novizen-Paare in drei verschiedenen Räumen untergebracht. Die Räume werden mit allen nötigen Hilfsmitteln ausgestattet. Dazu gehört unter anderem: eine Pinnwand, Befestigungsmaterial für die Kärtchen sowie Klebepunkte in Farben gelb, grün und blau. Die Teilnehmer tauschen zunächst ihre Karteikarten aus. Jeder Teilnehmer soll sich dann den Kartenstapel des Team-Partners anschauen, ihn zu einem Arbeitsprozess sortieren und die Karten mit den Arbeitsschritten untereinander an die Pinnwand aufhängen. Dabei sollen die Teilnehmer versuchen, sich in die Rolle ihres Partners zu versetzen und sich zu fragen, wie er vorgehen würde und warum er ggf. andere Schritte gewählt oder einzelne Schritte weggelassen hat. Anhand dieser Aufgabe sollen die Teilnehmer feststellen, was ein Mitarbeiter bei einem Arbeitsschritt jeweils wissen bzw. können muss, um kritische Stellen im Prozess zu erkennen.

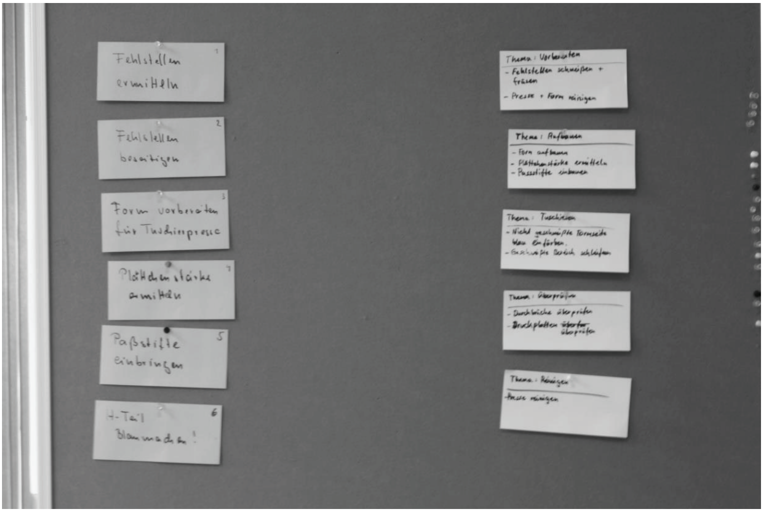


Abbildung 6. Arbeitsprozessschritte zweier Tandem-Partner
Quelle: Eigene Darstellung

Im folgenden Arbeitsauftrag sollen die Teilnehmer sich die Arbeitsprozessdokumentation ihres Teampartners kritisch anschauen, um festzustellen, welche Kärtchen oder Prozessschritte sie nicht verstehen. Die Stellen, an denen die Teilnehmer ihren Partner etwas fragen wollen, sollen sie mit einem gelben Punkt markieren. Nachdem alle gelben Punkte aufgeklebt sind, werden gegenseitig Verständnisfragen gestellt. Neue Aspekte, die in diesem Gespräch entstehen, werden ergänzt, um die individuellen Prozessbeschreibungen klarer zu machen. Nach dieser Aufgabe präsentiert jedes Zweierteam die Ergebnisse dem Workshop-Moderator zur weiteren Ergänzung und Verbesserung.

Im nächsten Schritt sollen die Tandem-Partner ihre Arbeitsabläufe vergleichen und Unterschiede zwischen ihrer und der Dokumentation des Partners erkennen. Aspekte, die nur in einem der Vorschläge auftauchen und übernommen werden sollen, wenn die Arbeitsabläufe zusammengeführt werden, werden mit einem blauen Klebepunkt markiert. Wiedersprüche in den Prozessbeschreibungen sollen sie mit den grünen Punkten markieren. In diesem Fall müssen sie sich später bei der Zusammenführung der Arbeitsprozessdokumentationen auf eine der beiden Sichtweisen einigen. Nachdem die Markierungen gesetzt worden sind, können die Teilnehmer nun ihre beiden Vorschläge zu einem zusammenführen. Die eingesetzten Klebepunkte sollen dabei das Zusammenführen unterstützen. Die Kärtchen, die mit blauen Punkten versehen worden sind, sollen in der zusammengeführten Version erscheinen, da sie jeweils nur in einer der Dokumentationen auftauchten, aber wichtig für den Prozessablauf sind. Bei den Kärtchen mit grün markierten Punkten muss entschieden werden, auf welche Sichtweise sich die Tandem-Partner einigen und welche Version sie in den gemeinsamen Vorschlag übernehmen.

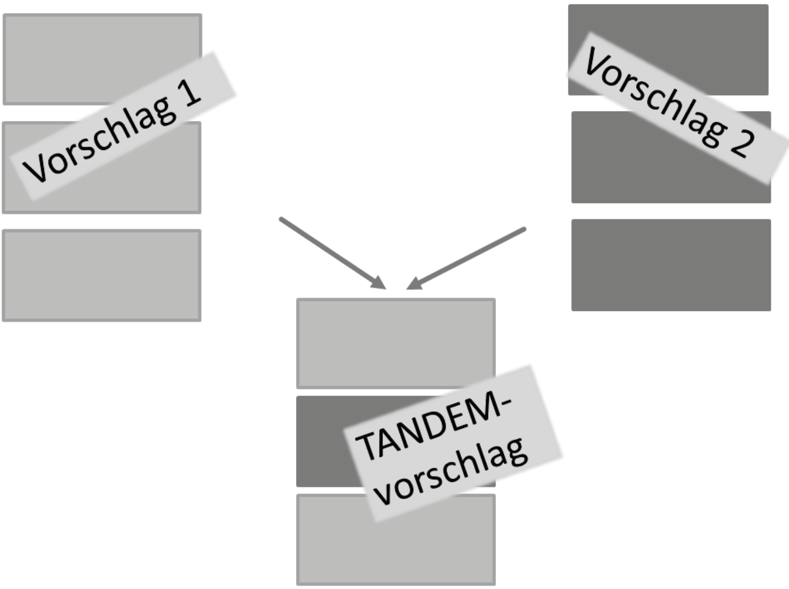


Abbildung 7. Das Zusammenführen der Vorschläge zu einem Tandemvorschlag
Quelle: Eigene Darstellung

Nun sollen die Zweierteams ihren gemeinsamen Arbeitsablauf fertigstellen und überprüfen, ob er alle wichtigen Informationen enthält. Anschließend sollen die Teilnehmer den Vorschlag mit in den Gruppenraum nehmen.

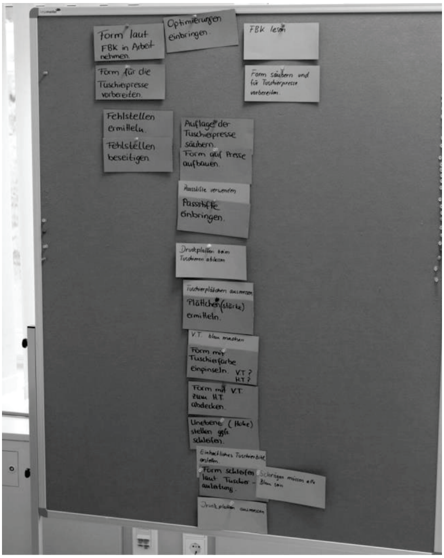


Abbildung 9. Beispiel eines Tandemvorschlags
Quelle: Eigene Darstellung

11.5.1.3 Dritte Phase

In der letzten Phase des Kickoffworkshops erarbeiten alle sechs Teilnehmer gemeinsam einen Teamvorschlag. Zunächst soll jedes Zweierteam seinen gemeinsamen Vorschlag der Gruppe vorstellen. Nach der Vorstellung wird über die Vorschläge diskutiert. Die Aspekte, die unverständlich sind, werden geklärt. Die Vorschläge werden miteinander verglichen. Die Gruppe hat hierbei den Auftrag, sich insbesondere mit den Unterschieden auseinanderzusetzen. Abweichende Meinungen zu Abfolge und Inhalt des Prozesses werden diskutiert. Die Teilnehmer begründen die Formulierungen ihrer Arbeitsschritte, tauschen ihre Ideen und Gedanken aus. Die Kärtchen aus unterschiedlichen Vorschlägen werden in eine gemeinsame Version zusammengeführt. Dabei werden einige Kärtchen außer Acht gelassen, falls sie zu den übernommenen nahezu identisch sind oder sich während der Diskussion als überflüssig erweisen. Außerdem werden einige neue Kärtchen geschrieben, die im Gespräch neu identifizierte Aspekte aufnehmen. Nach und nach wird der gemeinsame Vorschlag auf einer großen Tafel entwickelt.

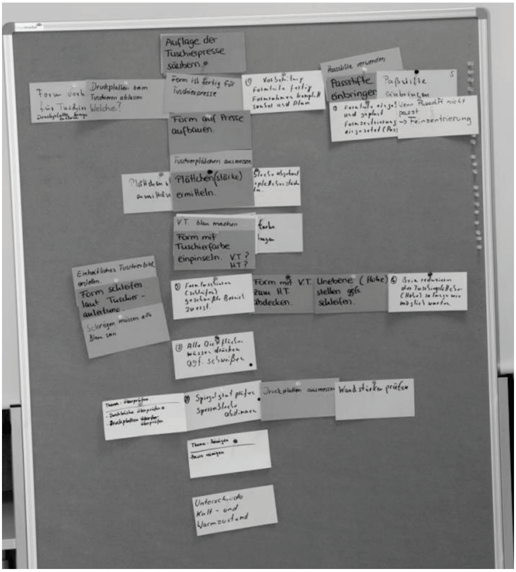


Abbildung 10. Beispiel eines Teamvorschlags
Quelle: Eigene Darstellung

Die nächste Aufgabe stellt ein Brainstorming dar. Alle Teilnehmer sammeln ihre Ideen dazu,

a. was ein Mitarbeiter wissen und können muss, um den einzelnen Arbeitsschritt zu bearbeiten;

b. welche Probleme in den Arbeitsschritten auftreten können und

c. in welchen anderen Bereichen ähnliches Wissen und Können auch gebraucht werden könnte.

Die Mitarbeiter schreiben zu allen Themen Ideen auf Kärtchen, die wiederum zu den entsprechenden Arbeitsschritten auf die Tafel geklebt wurden.

11.5.1.4 Endphase

Am Ende des ersten Workshops sind die Themen und eine Struktur für den Schulungsbaustein erfasst. Die Teilnehmer bekommen nun den Arbeitsauftrag, den Arbeitsprozess an ihrem Arbeitsplatz bis zum nächsten Workshop mit Ihrem Team-Partner einmal durchzuspielen. Dieses Durchspielen sollen sie mit Fotos, einer Beschreibung etc. dokumentieren. Zum Schluss werden die Teilnehmer darauf hingewiesen, was sie beim nächsten Workshop tun werden und es wird nach einem Feedback ihrerseits zu dem ersten Workshop gefragt.

Alle Teilnehmer bekommen innerhalb von wenigen Tagen eine Skizze der erstellten Arbeitsprozessbeschreibung in digitaler Form. Sie sollen sich bei der Erfüllung der Hausaufgabe daran orientieren und Änderungen vornehmen, die sie für sinnvoll halten. Bis zum nächsten Workshop bekommen alle Teilnehmer Unterstützung durch Coaching für Fragen bei der Hausaufgabe und der Dokumentation.

11.5.2 Ausarbeitungsworkshop

Das Ziel des Ausarbeitungsworkshops liegt darin, eine klare Beschreibung jedes einzelnen Arbeitsschrittes im Arbeitsprozess zu entwickeln, indem ein Lerngespräch mit Bildmaterial für alle Schritte durch die Teilnehmer erstellt wird.

Der Workshop ist genau wie der Kickoffworkshop in vier Phasen eingeteilt:

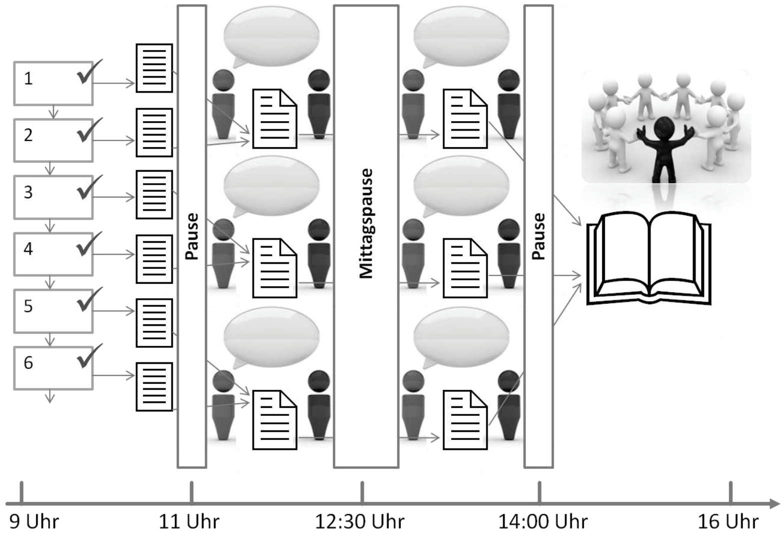


Abbildung 11. Aufbau des Ausarbeitungsworkshops
Quelle: Eigene Darstellung

11.5.2.1 Erste Phase

In der ersten Phase sollen die Teilnehmer den gesamten Arbeitsprozess überprüfen. Der Arbeitsprozess wird hierzu vor dem Workshop wieder mit Hilfe von Karteikarten an einer Tafel für alle sichtbar befestigt. Er wird ergänzt mit den

Bildern, die Teilnehmer während der Hausaufgabe gemacht haben. Die Bilder, die von dem Moderator keinem Prozessschritt zugeordnet werden konnten, liegen auch bereit, damit die Teilnehmer sie während des Workshops einsetzen können. Zunächst sollen die Teilnehmer überprüfen, ob der Titel zum jeweiligen Arbeitsschritt im Prozess passt oder eventuell umformuliert werden muss. Des Weiteren sollen die Teilnehmer auf zusätzliche Schritte hinweisen, die ihnen während der Hausaufgabe aufgefallen sind und die noch aufgenommen werden müssen.

Der Moderator des Workshops prüft hierfür zusammen mit den Teilnehmern alle Prozessschritte, indem er alle Schritte vorliest. Nach jedem Schritt wird nach Verbesserungsmöglichkeiten oder Umformulierungen gesucht, sofern diese notwendig sind. Außerdem soll die Reihenfolge der Schritte nochmals überprüft werden.

11.5.2.2 Zweite Phase

In der zweiten Phase des Workshops sollen die Teilnehmer eine eigene Beschreibung der Arbeitsschritte anfertigen.

Für diese Aufgabe erhalten alle Teilnehmer Laptops mit dem Gruppenunterstützungssystem thinkTank 3 (GroupSystems). Den Teilnehmern wird zusätzlich der Umgang mit dem Programm erklärt.

Die Inhalte des Kickoffworkshops (die Prozessdokumentation) wurden von dem Moderator bereits im Voraus in die Software eingegeben. Das Programm wird für die Erfüllung dieser und der folgenden Aufgabe (Lerndialoge) genutzt. Das Gruppenunterstützungssystem ermöglichte es, die Inhalte, die die Teilnehmer generiert haben, in Echtzeit für alle zu aktualisieren. Jeder Teilnehmer kann jederzeit prüfen, ob die Schritte alle wichtigen Informationen enthalten und falls nötig sofort Änderungen vornehmen.

Alle Prozessschritte werden zwischen den Teilnehmern zur Bearbeitung aufgeteilt. Jeder Teilnehmer bekommt mehrere Prozessschritte, an denen er arbeiten soll. Für jeden Arbeitsschritt soll man alles, was zu wissen und zu tun ist, stichpunktartig in thinkTank festhalten. Die Teilnehmer sollen lesen, was zum jeweiligen Arbeitsschritt bereits vorhanden ist und wichtige Punkte ergänzen, die aus ihrer Sicht im Schulungsbaustein behandelt werden sollten. Sie sollen mit dem Prozessschritt beginnen, der ihnen zugeteilt wurde und wenn sie fertig sind, zum nächsten Arbeitsschritt wechseln. Wenn ein Teilnehmer mit seinen Prozessschritten komplett fertig ist, kann er die Bearbeitung der weiteren Schritte, die einem anderen Teilnehmer zugeteilt worden sind, vornehmen. Dieses Vorgehen hat zum einen das Ziel, die neu gewonnenen Erkenntnisse festzuhalten. Zum anderen, kann in relativ kurzer Zeit eine wertvolle Grundlage für die nächste Phase geschaffen werden: es entsteht für jeden Prozessschritt ein Handzettel mit den Kernthemen für die Ausarbeitung.

11.5.2.3 Dritte Phase

In dieser Phase findet die Entwicklung der Lerngespräche statt. Die Gruppe wird hierzu in drei Zweierteams (mit einem erfahrenen und einem unerfahrenen Mitarbeiter) geteilt. Das besondere an dieser Aufgabe ist, dass der Dialog nicht mündlich geführt wird, sondern chat-ähnlich im Gruppenunterstützungssystem. Dadurch soll erreicht werden, dass keine Informationen oder Ideen verloren gehen, sondern alles in digitaler Form festgehalten wird. Zu jedem Arbeitsschritt soll der unerfahrene Partner anhand des vorher erstellten Handzettels dem erfahrenen Kollegen Fragen zu dem jeweiligen Schritt stellen.

Abbildung 12 zeigt beispielhaft die Fragen-Antwort-Logik des Lerndialogs.

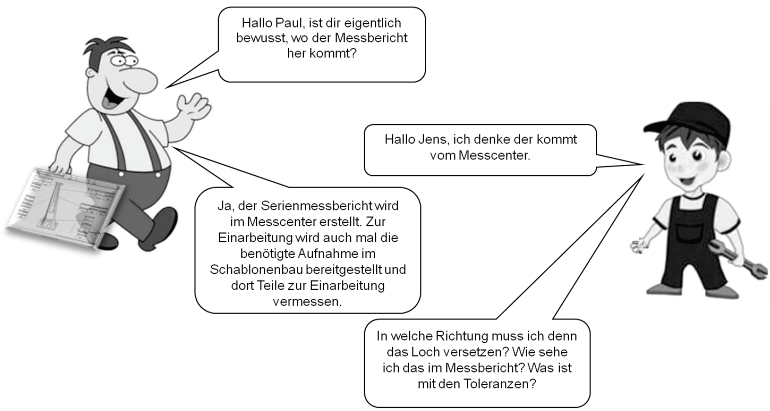


Abbildung 12. Beispiel aus dem Lerndialog
Quelle: Eigene Darstellung

Zunächst bekommt jedes Zweierteam Arbeitsschritte zugeteilt. Zu jedem Ihrer zugeteilten Arbeitsschritte sollen sie eine Unterhaltung entwickeln: Einer von ihnen soll dem anderen den Arbeitsschritt erklären. Der andere hat die Aufgabe, kritische Fragen zur Erklärung zu stellen. Wo es sinnvoll ist, sollen sie Bilder zu den

Erklärungen hinzufügen oder eigene Skizzen anfertigen. Es sollen Lerngespräche aus Fragen und Antworten entwickelt werden, durch welche neue Mitarbeiter den Prozess erlernen können. Die Handzettel aus der vorherigen Aktivität dienen den Teilnehmern dabei als Gedankenstütze, damit sie alle wichtigen Inhalte thematisieren.

Die jungen Mitarbeiter sind nicht im gleichen Maße mit dem Thema vertraut, wie die erfahrenen. Genau dies erweist sich häufig als großer Vorteil bei der Kommunikation zwischen beiden. Die erfahrenen Mitarbeiter sind Experten auf ihrem Gebiet, haben großes Fachwissen und langjährig entwickeltes Können. Aber sie führen viele Arbeitsvorgänge routiniert und unbewusst aus. Die jungen Mitarbeiter hinterfragen dagegen jede Aktivität, da diese Abläufe noch neu für sie sind. Daher kann im Dialog zwischen beiden Seiten viel mehr festgehalten werden als die erfahrenen Mitarbeiter alleine dokumentiert hätten. Der Vorteil, der durch die Beteiligung der erfahrenen Mitarbeiter entsteht, ist offensichtlich: Sie kennen bereits verschiedene Herangehensweisen und „Tricks“, die abhängig von entstandenen Arbeitsbedingungen oder -situationen angewandt werden können, damit der Arbeitsprozess reibungslos verläuft. Sie wissen zudem bereits, welche Fehler und Probleme auftreten können und wie diese zu beheben sind.

11.5.2.4 Endphase

In der vierten Phase soll die Zusammenführung der Lerngespräche stattfinden.

Jedes Zweierteam trägt nun seine Unterhaltung vor. Die Arbeitsschritte werden den Kollegen zusammen mit dem Bildmaterial, das genutzt werden soll, erklärt und gezeigt. Die Zuhörer sollen währenddessen Kommentare geben, falls:

- sie den Eindruck haben, dass an einer Stelle etwas fehlt, was zur Durchführung des Schrittes notwendig wäre;
- etwas unklar oder nicht ausführlich genug erklärt wurde oder
- an einer Stelle eine zusätzliche Skizze oder ein Bild zur Erklärung beitragen könnte.

Des Weiteren werden alle Schritte erneut durchgegangen. Die Lücken, die nicht direkt vor Ort geschlossen werden können (z.B. fehlende Bilder oder Anleitungen), werden als Arbeitsauftrag festgehalten, den die Teilnehmer wieder als Hausaufgabe bearbeiten müssen. Außerdem sollen die Teilnehmer Ideen für Übungsaufgaben und Tests sammeln, die neuen Mitarbeitern das Erlernen erleichtern würden. Zusätzlich werden die Teilnehmer gebeten, den Entwurf des Lerndialogs mit anderen Mitarbeitern im Betrieb zu erproben und Feedback dazu einzuholen.

Am Ende des Workshops bekommen die Teilnehmer Informationen dazu, was sie beim nächsten Termin erwarten wird. Es wird zudem nach Verbesserungsvorschlägen und Feedback seitens der Teilnehmer gefragt.

Bis zum nächsten Workshop bekommen alle Teilnehmer Unterstützung durch Coaching für die Hausaufgabe. Muster für unterschiedliche Übungsaufgaben sowie der im Workshop entstandene Lerndialog werden den Teilnehmern zugeschickt.

11.5.3 Finalisierungsworkshop

Das Ziel des letzten Workshops ist es, das Lerngespräch mit weiterem Bildmaterial für alle Arbeitsschritte anzureichern, Übungs- und Testaufgaben zum Schulungsbaustein zu entwickeln und Ideen zum Einsatz der Schulungsmaterialien, zur Verbesserung des Workshopkonzepts und des dokumentierten Arbeitsprozesses zu sammeln.

Der Ablauf des Workshops wurde ebenfalls in vier Phasen geteilt:

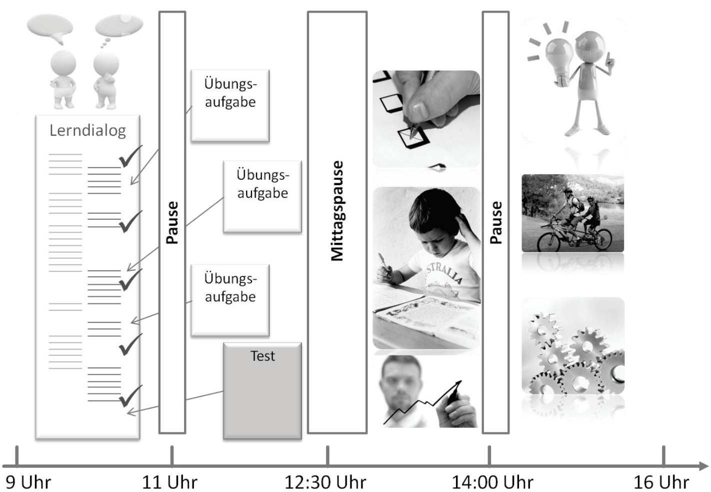


Abbildung 13.: Aufbau des Finalisierungsworkshops
Quelle: Eigene Darstellung

11.5.3.1 Erste Phase

Der Lerndialog, der im Ausarbeitungsworkshop entstanden ist, wird zusammen mit den Änderungen, die Teilnehmer noch nachträglich vorgenommen und per E-Mail an den Workshop-Moderator geschickt haben, ausgedruckt und an der Tafel befestigt.

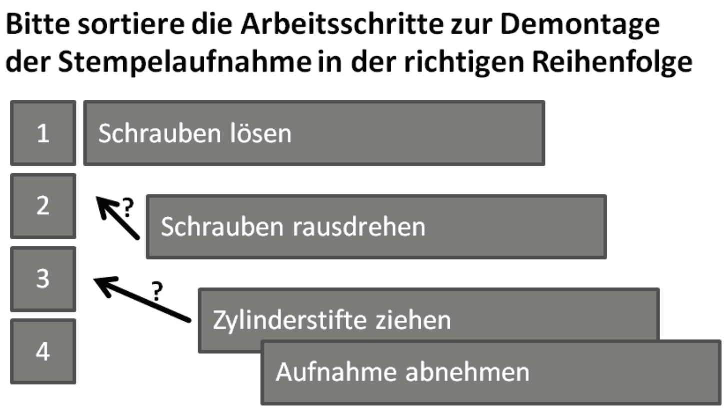
Als erstes wird der Lerndialog überprüft. Die Teilnehmer sollen nachkontrollieren, ob alle Arbeitsschritte richtig aufbereitet sind und überlegen, welche Ergänzungen noch notwendig sind, damit der Schulungsbaustein komplett ist. Dazu erhalten die Teilnehmer Karteikarten, um Notizen auf diesen zu verfassen und an die Tafel zu dem jeweiligen Arbeitsschritt zu hängen. Anschließend werden alle Anmerkungen durchgegangen und der Lerndialog vervollständigt.

11.5.3.2 Zweite Phase

In der zweiten Phase werden die Übungsaufgaben und ein Test zur Selbstkontrolle für neue Mitarbeiter erstellt.

Jeweils zwei Team-Partner sollen 3 Übungsaufgaben zu unterschiedlichen Arbeitsschritten aus dem Lerndialog wählen und diese auf Papier so ausarbeiten, dass die anderen Kollegen sie testen können. Zur Orientierung werden den Teilnehmer einige Beispiele für die verschiedene Typen von Übungsaufgaben vorgeschlagen, z.B. Multiple Choice Aufgaben, Sortieraufgaben etc.

Beispiel 1:



Beispiel 2:

Abbildung 14. Beispiele für Übungsaufgaben
Quelle: Eigene Darstellung

11.5.3.3 Dritte Phase

In der nächsten werden die Aufgaben geprüft. Zu diesem Zweck sollen die Teilnehmer ihre Übungsaufgaben den anderen Zweierteams vorstellen. Gegenseitig wird geprüft, ob die Aufgaben der anderen Teams klar formuliert, nicht zu leicht und nicht zu schwer für einen neuen Mitarbeiter sind.

11.5.3.4 Endphase

In der vierten Phase wird Feedback von den Teilnehmern dazu eingeholt, wie die Schulungsbausteine bei ihrer Arbeit eingesetzt werden könnten und was im Unternehmen gegeben sein müsste, damit sie den Schulungsbaustein gut nutzen könnten. Außerdem sollen die Teilnehmer überlegen, wie das Lernen und die Wissensweitergabe in ihrem Bereich sonst noch verbessert werden könnten.

Schließlich sollen die Teilnehmer Feedback dazu geben, welche Verbesserungsmöglichkeiten für den dokumentierten Arbeitsprozess ihnen bei der gemeinsamen Erarbeitung des Schulungsbausteins aufgefallen sind oder wie man den Arbeitsprozess einfacher machen könnte. Weiterhin werden die Teilnehmer gefragt, was sie bei der Erstellung des Schulungsbausteins für sich persönlich gelernt haben und welche Ideen sie von ihren Arbeitskollegen zum Arbeitsprozess übernehmen konnten.

Ebenso wird Feedback zu der gesamten Workshop-Reihe eingeholt. Es wird gefragt, was den Teilnehmern an dem Workshopkonzept gefallen hat, was sie verbessern würden und was an dem Ablauf, der Betreuung, dem Inhalt des Workshops oder den Hausaufgaben geändert werden sollte.

Zum Schluss bekommen die Teilnehmer Informationen dazu, was weiter mit den Schulungsbausteinen passieren wird und wie sie endgültig aufbereitet und einschließend eingesetzt werden.

11.5.4 Fragebögen

Am Anfang und am Ende jedes Workshops werden die Teilnehmer gebeten, standardisierte Fragebögen auszufüllen. Die Pre- (vor dem Workshop) und Post-Fragebögen (nach dem Workshop) sind unterschiedlich konzipiert. In erstem Fragebogen werden einige demographischen Daten zu den Teilnehmern gesammelt sowie ihre Selbsteinschätzung zum geteilten Wissen erfragt. In dem zweiten Fragebogen werden zusätzlich die Themen Lernverhalten der Gruppe und Gruppeneffektivität angesprochen. Der erste Fragebogen zeigt somit das erwartete Ausmaß an geteiltem Wissen mit dem Teampartner, der zweite – das tatsächliche. So kann festgestellt werden, ob die Teilnehmer mehr oder weniger gemeinsames Wissen haben als sie anfangs gedacht hatten und wie sich dieses Wissen im Laufe der Workshops weiter entwickelt hat.

Zur Datenauswertung werden die Fragebögen in SPSS erfasst und anschließend ausgewertet.

11.6 Erkenntnisse

Der folgende Abschnitt stellt die zentralen Erkenntnisse der explorativen Fallstudie vor. Zum einen wird diskutiert, welche Herausforderungen und Interaktionsmechanismen innerhalb der Arbeitsgruppen im Projekt beobachtet werden konnten und wie der Wissenstransfer in der Experten-Experten sowie Experten-Novizen-Interaktion unterstützt wurde. Zum anderen wird vorgestellt, welche organisatorischen Rahmenbedingungen im Projekt identifiziert werden konnten, die die Umsetzung des Wissenstransferprozesses in Organisationen fördern oder behindern können.

11.6.1 Erkenntnisse über Mechanismen zur Wissensintegration in heterogenen Arbeitsgruppen

In der Interaktion in den altersgemischten Arbeitsgruppen konnten verschiedene wiederkehrende Muster beobachtet werden, die Bedeutung für die Gestaltung von Wissenstransferprozessen haben.

Zunächst wurde deutlich, dass der Wissenstransfer zwischen Experten und Novizen mit anderen Herausforderungen konfrontiert ist als die Weitergabe von Wissen zwischen Experten mit ähnlichem Vorwissen. Experten innerhalb des Projektes zeigten in der Regel schon zu Beginn der Workshopserie eine hohe Überschneidung an initialem Wissen und einen hohen Grad an gemeinsamem Verständnis (Bittner and Leimeister 2014) zum Arbeitsprozess. Sie verfügten über umfangreiches Fachwissen und implizites Erfahrungswissen. Herausforderungen in der Experten-Experteninteraktion lagen daher insbesondere in der Herstellung von Bewusstsein über dieses unbewusste Wissen (Ambrose et al. 2010) und der Fähigkeit zur Explikation. Missverständnisse traten dann auf, wenn sich die ausgereiften mentalen Modelle der einzelnen Experten in wichtigen Details unterschieden, die bei der mündlichen Diskussion des Arbeitsprozesses erst spät entdeckt wurden. Außerdem war es in einigen Fällen notwendig, einen Kompromiss für eine gemeinsame Dokumentation auszuhandeln, wenn sich die jahrelang etablierten Vorgehensweisen der Experten durch verschiedene Gewohnheiten und Geschmäcker unterschieden, von denen keine offensichtlich überlegen war (Kolfschoten et al. 2009). Als geeignete Mechanismen zur Unterstützung des Wissenstransfers zwischen Experten erwiesen sich vor allem die frühe und detaillierte Dokumentation und Visualisierung von Zwischenergebnissen aus der Einzel- und Gruppenarbeit. Die textlichen und bildlichen Dokumentationen dienten als „boundary objects“ (Koskinen and Mäkinen 2009), anhand derer Unterschiede im Verständnis aufgedeckt werden konnten und Konsensentscheidungen kontinuierlich festgehalten wurden. Verhandlungen über konfliktäre Sichtweisen wurden durch die Entkopplung von Argumenten und Akteuren erleichtert. Im Gruppenunterstützungssystem dokumentierte Argumente und Positionen wurden im Ausarbeitungsworkshop in der Gesamtgruppe sachlich diskutiert. So fiel es einzelnen Experten leichter, sich für alternative Ansätze zu öffnen, als wenn sie ihren eigenen Ansatz verteidigen hätten müssen.

Der Wissenstransfer zwischen Experten und Novizen war in den betrachteten Gruppen von anderen Herausforderungen und Interaktionsmechanismen gekennzeichnet. Experten und Novizen waren zu Beginn der Zusammenarbeit häufig unsicher, welchen Wissensstand ihr TANDEM-Partner zum Arbeitsprozess hat und wie eine gemeinsame Wissensdokumentation stattfinden kann. Für Experten war unklar, auf welches Vorwissen der Schulungsbaustein aufbauen kann, welche Themen und Fähigkeiten für Novizen Herausforderungen darstellen und welche Fachsprache für Novizen verständlich ist. Novizen waren oft zunächst unsicher, was sie selbst zum Zusammenarbeitsprozess beitragen könnten. Diejenigen, die selbst den Arbeitsprozess noch nie durchgeführt hatten, hatten in den ersten Arbeitsphasen Probleme, eine mentale Struktur des Arbeitsprozesses aufzubauen, in die sie neue Informationen der Experten einordnen können. So waren die individuellen Arbeitsprozessdokumentationen, die Novizen in der Anfangsphase des Kick-off-Workshops aufschrieben, oft sehr kurz und unvollständig. Fragen an die Experten waren zu Beginn meist auf einer sehr allgemeinen, oberflächlichen Faktenebene angesiedelt oder beschäftigten sich mit der Klärung von Fachbegriffen.

Um einen ersten Überblick über die Heterogenität des Wissenstandes zu gewinnen, eine Diskussionsgrundlage für die paarweise Interaktion zu schaffen und die Teilnehmer für ihre Experten- bzw. Novizenrollen zu sensibilisieren, erwies sich die initiale Einzelarbeit und der Austausch über die Individualdokumente als geeignet. In der Experten-Novizen-Interaktion stellte sich zudem die IT-gestützte Frage-Antwort-Technik in Chat-Form zur Ausarbeitung der Lerndialoge im zweiten Workshop als besonders hilfreich heraus. Die paarweise Interaktion trug dazu bei, dass auch unerfahrene Novizen mit ihren gezielten Fragen einen wichtigen Beitrag zum Gruppenprodukt leisteten, die sich in der Großgruppendiskussion eher zurückhielten. Experten wurden durch die Frage-Antwort-Dynamik dabei unterstützt, unbewusstes oder vermeintlich unwichtiges Wissen zu explizieren und Niveau und Detailgrad der Dokumentation auf das Vorwissen von Novizen auszurichten.

11.6.2 Erkenntnisse zur Organisation von Wissenstransferprozessen in Organisationen

Die folgenden Erkenntnisse resultieren in erster Linie aus dem Teilnehmerfeedback zu den einzelnen Workshops und Teilnehmerinterviews, aber auch aus Rückmeldungen beteiligter Führungskräfte und der Beobachtung kritischer Situation und Abweichungen im Workshopprozessablauf in einzelnen Teams.

In der Phase der Vorbereitung der Workshopserie stellten sich insbesondere folgende Faktoren als erfolgskritisch für den reibungslosen und produktiven Ablauf der Workshopserie heraus:

- Eine genaue Themenspezifikation unter Einbindung von Teilnehmern im Vorfeld der Workshopserie stellt die Auswahl eines für die Mitarbeiter verständlichen, relevanten Themas und die Identifikation mit dem Workshopziel sicher. Die verhindert Verzögerungen in der Themenvorstellungsphase des ersten Workshops und ist insbesondere dann wichtig, wenn Führungskräfte im Workshop selbst nicht anwesend sind, um Nachfragen zu klären.
- Intensive Kommunikation mit den direkten Vorgesetzten über das Projektziel, den Umfang der notwendigen Freistellung und die Unterstützung durch die Führungskraft ist notwendig. Teilnehmer äußerten deutlich höhere Motivation zur Beteiligung, wenn sie von ihren Vorgesetzten Vorabinformationen zum Projekt erhalten hatten und den Eindruck bekommen hatten, dass der Vorgesetzte ein Interesse am Projektablauf und Ergebnis hat.
- Die Zielgruppe des zu entwickelnden Schulungsmaterials sollte vorab explizit geklärt werden. Je nachdem, ob der Schulungsbaustein als Nachschlagewerk für wenig erfahrene Fachkräfte oder als ausführliches Lehrbuch für Auszubildende ohne Vorwissen im eigentlichen Arbeitsprozess dienen soll, muss die Gruppe auf ein unterschiedliches Gruppenergebnis hinarbeiten. Ziel und Format dieses Ergebnisses müssen vorab geklärt sein und klar kommuniziert werden.

Während der Workshopserie sind folgende Faktoren besonders zu beachten:

- Die Hausaufgabenbearbeitung mit dem jeweiligen TANDEM-Partner zwischen den einzelnen Workshops stand in positivem Zusammenhang mit dem Detailgrad des erarbeiteten Schulungsbausteins und der Entwicklung des gemeinsamen Verständnisses zwischen den Teilnehmern. Eine organisierte Freistellung der Teammittglieder (gleichzeitige Freistellung der TANDEM-Partner, Beachtung von Schicht- und Urlaubsplanung) ist daher entscheidend, um die Rücküberprüfung mit dem Arbeitsprozess im Betrieb und die Vernetzung der Teilnehmer über das Projekt hinaus sicherzustellen.

- Für die Dokumentation des Arbeitsprozesses am Arbeitsplatz ist es zum einen notwendig, dass die Teilnehmer zum richtigen Zeitpunkt Zugang zu den benötigten Maschinen haben. Zum anderen muss die technische Infrastruktur sichergestellt werden, um Fotos, Handbücher etc. zu erfassen, bearbeiten und übermitteln (z.B. Kamera, Fotografieerlaubnis, Speichermedien, PC- und Internetzugang). Es stellte sich als förderlich für die Praxistauglichkeit der Lernmaterialen heraus, wenn zudem während eines der Workshops (Ausarbeitungs- oder Finalisierungsworkshop) die Möglichkeit bestand, gemeinsam am Arbeitsplatz den Zwischenstand des Schulungsbausteins zu testen und zu validieren.
- Bei Einsatz von Gruppenunterstützungssystemen in der Zusammenarbeit ist es zudem notwendig, insbesondere Teilnehmer, die weniger IT-affin sind oder im Arbeitsalltag nicht oder wenig mit Computern in Kontakt kommen, langsam an die Techniknutzung heranzuführen. Neben einer Einführung anhand von Nutzungsbeispielen war es insbesondere sinnvoll, auf die Vorteile der IT-Unterstützung (paralleles Arbeiten, Dokumentation für spätere Prozessschritte, Anonymität der Beiträge) explizit hinzuweisen. Auch die paarweise Zusammenarbeit von Experten und Novizen konnte dazu beitragen, dass Teilnehmer sich gegenseitig bei Technikproblemen unterstützten und insbesondere ältere Teilnehmer sich nicht bloßgestellt fühlten.

Nach Abschluss der Workshopserie sollten folgende organisatorische Aspekte beachtet werden:

- Aus der Befragung der Teilnehmer ergab sich, dass Aktualität der Lernmaterialien ein zentraler Faktor für die Akzeptanz und Nutzung ist. Um die Aktualität sicherzustellen, wird empfohlen, einen Paten für jeden Schulungsbaustein zu benennen und den Schulungsbaustein in digitaler, bearbeitbarer Form zur Verfügung zu stellen, damit Verbesserungen oder neue Erkenntnisse direkt von den Mitarbeitern eingepflegt werden können.

- Desweiteren stellte sich heraus, dass die Nutzung von Führungskräften unterstützt werden muss. Dazu gehören das Zur-Verfügung-stellen von Zeit im Arbeitsalltag zur Nutzung der Materialien ebenso wie die

Information über neu entstandene Schulungsbausteine und Anreizsysteme zur Nutzung der Materialien bei der Einweisung neuer Mitarbeiter sowie als Nachschlagewerk.

- Außerdem zeigte sich, dass Wissenstransfermechanismen zwischen Experten und Novizen, die im TANDEM-Prozess implementiert sind, auch in die Organisationskultur und den Arbeitsalltag einfließen sollten. So zeigen die Befragungen und Beobachtungen, dass Wissenstransfer zwischen Mitarbeitergenerationen nur umfassend und nachhaltig geschehen kann, wenn sich die Mitarbeiter auch nach Projektende austauschen, ein offenes Klima herrscht (Nachfragen-trauen und Weitergeben-wollen). Nicht zuletzt muss Wissenstransfer rechtzeitig vor Ausscheiden der Experten angestoßen und kontinuierlich unterstützt werden, da implizites Erfahrungswissen nicht innerhalb kurzer Zeit vollständig übertragen werden kann.

11.7 Fazit

Dieser Beitrag präsentiert das TANDEM-Workshopkonzept als Lösungsansatz zur Unterstützung des Wissenstransfers in altersdiversen Arbeitsgruppen in der betrieblichen Praxis. In der vorgestellten Fallstudie wird anhand der Pilotierung des Workshopkonzeptes mit altersdiversen Facharbeitern in der Automobilindustrie analysiert, welche unterschiedlichen Herausforderungen sich im interpersonalen Wissenstransfer unter Experten bzw. zwischen Experten und Novizen bei der kollaborativen Zusammenarbeit an gemeinsamem Material ergeben. Es wird diskutiert, wie die Kollaborationstechniken im TANDEM-Workshopprozess gezielt dabei helfen, diesen Herausforderungen zu begegnen. Wissensmanagement-verantwortlichen werden somit validierte Techniken und Vorgehensweisen an die Hand gegeben, mit denen altersdiverse Arbeitsgruppen strukturiert bei der Dokumentation von Wissen in Schulungsbausteinen begleitet werden können. Aus den Erkenntnissen aus der Pilotierung werden ergänzend organisatorische Rahmen-bedingungen erläutert, die sich als erfolgskritisch für die Implementierung des Workshopprozesses und die Qualität seiner Ergebnisse herausgestellt haben. Kollaborationsforscher und –praktiker können den TANDEM-Workshopprozess anhand dieser Erkenntnisse auf Wissenstransferherausforderungen in anderen Organisationen übertragen. Die Weitergabe, Dokumentation und Erhalt von erfolgskritischem Erfahrungswissen unabhängig von einzelnen Wissensträgern soll damit nachhaltig verbessert werden.

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12 Theoretical Contributions of the Thesis

As outlined in section three, this thesis follows an action research approach to derive design guidelines and a technique for evoking team learning mechanisms for Shared Understanding. It targets an important class of practical challenges, building Shared Understanding in heterogeneous work groups to increase team effectiveness. A novel collaboration technique design should provide an improved solution to these challenges. Therefore, the thesis makes a design theory contribution by identifying non-intuitive design choices and creating well-documented, more reliable collaborative work practices. On the other hand, the thesis aims to build on and contribute to the theoretical knowledge base of Shared Understanding research. Thus, theoretical contributions of both descriptive and prescriptive knowledge can be derived from this work (Gregor and Hevner 2013):

a) Descriptive knowledge as “the ‘what’ knowledge about natural phenomena and the laws and regularities among phenomena” (Gregor and Hevner 2013): Shared Understanding as a complex and fuzzy phenomenon, it’s antecedents and effects as well as the mechanisms leading to the construction of Shared Understanding are still not fully understood. The exploration of Shared Understanding in real world and experimental settings in this thesis make a contribution to the descriptive knowledge base in the form of:

- A conceptualization and definition of the phenomenon Shared Understanding (see section 12.1).
- The exploration of measurement approaches for Shared Understanding (see section 12.2).
- An application of van den Bossche et al.‘s model of team learning behaviors (van den Bossche et al. 2011) to a real world setting (see section 12.3).
- Proposed adaptions of van den Bossche et al.‘s model of team learning behaviors based on the expanded understanding of the determinants of Shared Understanding in group work (see section 12.4).

b) Prescriptive knowledge as the ‘how’ knowledge of human-built artifacts: This work makes its core contributions with the artifacts developed and the implications for design theory that can be drawn from it. In particular, the MindMerger compound thinkLet for Shared Understanding (section 12.5) and the knowledge management process it is embedded in (section 12.6) are specific documented design artifacts to solve the real world problem. Furthermore, nascent design theory on a more general level is developed: The design guidelines derived from van den Bossche et al.'s model of team learning behaviors (van den Bossche et al. 2011) to ground the MindMerger as well as the design of further clarification techniques (section 12.7), the MindMerger compound thinkLet as a reusable technique for clarification (section 12.8), and the design principles for clarification derived from the exploratory investigation (section 12.9).

12.1 Conceptualization of Shared Understanding

Prior research shows a broad and heterogeneous picture of Shared Understanding. Many related constructs, such as team mental models, group cognition etc. have been discussed in different research streams and no unique widely accepted conceptualization has emerged. However, without a clear conceptualization of the phenomenon Shared Understanding, theorizing and designing becomes a challenge with a moving target. This thesis contributes to clarifying the fuzzy construct Shared Understanding by exploring it in depth in different practical settings and from an intense conceptual analysis. Throughout the action research study, a new definition of Shared Understanding has evolved based on prior work. I define Shared Understanding as *the degree to which people concur on the value of properties, the interpretation of concepts and the mental models of cause and effect with respect to an object of understanding (Bittner and Leimeister 2014).* This definition takes into account different domains of understanding as a dynamic state that can change over time due to group interaction. From this conceptualization, conclusions for necessary characteristics of measurement instruments can be drawn. For example, they need to be able to measure gradual changes at several points in time and take into account different domains, from interpretation of concepts to causal interpretations. Furthermore, as Shared Understanding is not seen as static, design efforts can aim to influence the degree of Shared Understanding within a group. The definition has been validated for its feasibility for the situations investigated within the scope of this thesis and should be challenged in other cases, were Shared Understanding is of importance.

12.2 Shared Understanding Measurement

Due to the multifaceted nature of Shared Understanding, its measurement is a complex challenge. No conclusive measurement instrument was available from literature that would cover the dynamic, gradual nature of Shared Understanding and reflect the challenge of explicating understanding as a cognitive state sufficiently. In this thesis, I use and explore different approaches to measure Shared Understanding. In the publications within this thesis, qualitative (e.g. expert evaluation of the mental model representations) as well as quantitative approaches (e.g. number of concepts in individual and team mind maps) are used to capture Shared Understanding. Self-assessment by participants in questionnaires is complemented with the analysis of individual and team mental model representations. From the experiences in the different settings at hand, I conclude that whenever possible, several types of measurement should be combined to allow for a holistic view on the phenomenon. If the relevant data is accessible, visual representations of the individual mental models should be collected before and after the collaborative work practice. Self-assessment of Shared Understanding showed similar increases of Shared Understanding from pretest to posttest measurements in the cases at hand. However, especially for newly formed ad hoc teams with no shared collaboration history, assessing their initial degree of Shared Understanding turned out to be difficult. Including objective measures for mental model representations can help to overcome these limitations. Asking participants to think about their mental models of the task at hand and visualize them can at the same time be a first step towards building a mutual and Shared Understanding. Thus it has more than just measurement benefits. In my research, I focused on measuring Shared Understanding of the group task as the object of understanding. I found it comparatively easier to assess Shared Understanding from the mental model representations, when the group task was relatively well defined (as in the student experiment). Analyzing mental model representations of more complex tasks, where not necessarily one right solution exists, needs detailed prior definition of the scope and level of detail that represents a "good degree of Shared Understanding". Future research should investigate, if for certain types of tasks (e.g. ideation tasks), an optimal degree of Shared Understanding exists that should not be exceeded to limit creativity. Furthermore, it should be discussed, whether measuring Shared Understanding on other objects of understanding (e.g. on the team member roles) deserves different measurement instruments.

12.3 Validation of Causal Model for Shared Understanding in Real World Application

Another theoretical contribution is related to the validation of van den Bossche et al.'s (2011) model of team learning behaviors. Van den Bossche et al. (2011) derive and test their model under controlled experimental conditions. As to my knowledge, no prior application to a practical real world setting has been published before. The usage in the action research study at hand shows that the team learning behaviors occur in the real world setting as expected, Shared Understanding increases consequently throughout collaboration, and team effectiveness rises. These findings are supported by our own validation in the student experiment in publication 5 (chapter 9). Thus, I conclude that van den Bossche et al.'s (2011) model can serve as a good starting point for analyzing Shared Understanding development, as well as antecedents and effects. Furthermore, with the rich insights on the complex real world situation, potentials for extending the model have been identified. For example, it might be fruitful to explore the effects of different team constellations, different kinds of tasks or other interaction behaviors than those in the original model on the relationships described in the model.

12.4 Proposed Adaption of van den Bossche et al.'s Model of Team Learning Behaviors

Van den Bossche et al. 's (2011) model on team learning behaviors turned out to be a valid source for design guidelines to inspire the initial MindMerger design. In all instantiations of the MindMerger, I tested the compound thinkLet for its ability to evoke construction, co-construction and constructive conflict. In general, I find evidence for increases in team learning behaviors, Shared Understanding and team effectiveness, as the model predicts. However, some insights from the studies in the scope of this thesis suggest potential adaptations of the model.

First, from the analysis of the items for team learning behaviors, we identified one item for constructive conflict that we excluded from the data collection and analysis in publication 5. The item "In this team, I share all relevant information and ideas I have") does not seem to reflect the definition of constructive conflict ("dealing with differences in interpretation between team members by arguments and clarifications") (van den Bossche et al. 2011) well but rather seems to measure willingness to disclose one's own understanding. Removing or replacing this item should be tested in future studies and might improve the model quality.

Second, we made an adaption to the measurement of Shared Understanding as opposed to the initial model. In their work, van den Bossche et al. (2011) measure Shared Understanding by the overlap of concepts and relationships in the mental model representations of individual participants. As outlined in section 12.2, individual mental model representations cannot be collected before and after collaboration in every setting. As they are available as by-products of the MindMerger process, I suggest comparing initial individual mental model representations with post-process team mental models and complementing this measure with self-assessment due to the discussed advantages of each approach. Future research should further investigate, which measurement approaches are best suited to reflect Shared Understanding in the model.

Third, findings from the action research project and the student experiment suggest that the team composition and complexity of the group task may have a major impact on the team interaction mechanisms that lead to more Shared Understanding. In the student experiment, we found significant evidence for a difference between treatment and control group only in the constructive conflict team learning behavior. This might be attributed to the relatively homogeneous background of the students, where constructing and co-constructing mutual understanding is relatively easy. Differences and conflicts might be relatively easy to detect in this constellation due to the similar mindset and language, but they might still need collaboration support for negotiating a shared perspective (constructive conflict). In the age and experience diverse groups of tool and dye makers in the action research project, detecting and explicating differences in understanding seemed to be much more an issue as participants felt less able to assess their colleagues mental models. This was attributed to the complexity of the work process to be documented as well as the lack in team history and shared experience. Therefore, I suggest to consider heterogeneity of the group and task complexity as potential moderators in the model on Shared Understanding construction.

12.5 MindMerger Instantiation

In this thesis, two implementations of the final MindMerger technique are documented as a contribution to the prescriptive knowledge base for Collaboration Engineering design research.

In the action research project in publications 3 and 4, an instantiation of the MindMerger compound thinkLet in a real world knowledge management challenge is described as part of a larger workshop process. The main contribution of this instantiations lies in providing scripts for collaboratively building a shared process structure of a complex work process in teams of novices and experts. Another distinctive feature of the instantiation is the iterative use of the MindMerger to build Shared Understanding between two actors first and later integrating it in a larger group of six people. The workshop agenda and the lessons learned from the instantiation can be used by Collaboration Engineering scholars and researchers from related disciplines to build similar solutions.

The second extensive documentation of an implementation is provided in publication 5. The agenda shows, how the MindMerger compound thinkLet can be implemented within less than an hour to build Shared Understanding on a well specified topic among two team members each. All prompts and questions are documented to provide guidance for similar implementations. This instantiation is an example of how the MindMerger can be used in small scale tasks, e.g. as a stimulating technique to encourage reflection and group learning on a specific topic within a lecture. The instantiation also provides evidence for the superiority of the MindMerger over unsupported collaboration in certain clarification tasks. Collaborating Engineers might thus use the provided documentation to implement the MindMerger in collaboration processes where clarification is needed.

12.6 A Collaboration Process Design for Knowledge Integration

In publications 6 and 7, a concept and its instantiation is presented that exceeds the scope of the MindMerger compound thinkLet. The collaboration process design describes a solution to the common organizational knowledge management challenge of documenting complex know-how of experienced employees and make it accessible to novices in a form that enables them to execute the work tasks themselves. The process design covers a three day workshop series that results in high quality learning material on the specified work process. Collaboration engineers can learn from this field implementation for the design of other collaborative knowledge integration practices in organizations.

12.7 Operationalization of Descriptive Model for Theory Motivated Design Through Design Guidelines

On the level of nascent design theory (Gregor and Hevner 2013), the design guidelines derived from van den Bossche et al.'s model (2011) to inform the MindMerger design deserve to be mentioned as a major contribution. With these general design guidelines presented in publication 2, the descriptive model is linked to prescriptive design recommendations for the first time. Thus, it makes the knowledge inherent to the model useable to designers of collaborative work practices. On the one hand, this knowledge has been used to make non-intuitive design choices for the theory motivated development of the MindMerger. On the other hand, the design guidelines can be used by other scholars to guide their design efforts for alternative techniques for Shared Understanding, e.g. to develop clarification techniques for large groups where the MindMerger design is not suitable. The approach taken in this work to derive the MindMerger from a theoretical model (van den Bossche et al. 2011) and develop it iteratively in an action research setting can serve as an idol process for collaboration practice design.

12.8 The MindMerger as a Building Block for the “Clarify” Pattern of Collaboration in Collaboration Engineering

Collaboration Engineering researchers have identified “clarify” – the process of moving from less to more Shared Understanding – as one of six recurring patterns of collaboration (Briggs et al. 2006). There has been a lot of fruitful research on other patterns of collaboration, e.g. “generate” (Shepherd et al. 1995; Reinig et al. 2007) and “build consensus” (Kolfschoten et al. 2009) that has led to validated standardized facilitation techniques (thinkLets (Briggs and de Vreede 2009)) that “can be used as conceptual building blocks in the design of collaboration processes” (Kolfschoten et al. 2006). Furthermore, theories have been developed from these efforts (Briggs 1994; Briggs et al. 2008; Briggs and Reinig 2010). Little attention, however, has been paid to the “clarify” pattern to-date, and Shared Understanding as a core construct within the clarify pattern is still a fuzzy phenomenon subject to conceptual confusion (Akkerman et al. 2007).

As little is known on what leads to Shared Understanding, practitioners need guidance on how to evoke processes for Shared Understanding deliberately and repeatedly. This thesis addresses this need of Collaboration Engineering researchers and practitioners by providing the MindMerger compound thinkLet that can be added to thinkLet collections as a building block for the clarify pattern in collaboration process design.

12.9 Design Principles for Clarification

In addition to the design guidelines from van den Bossche et. al. (2011)’s model that the MindMerger builds on, the exploration within this thesis leds to further design principles. Although of exploratory origin from one single setting, these principles can help to identify new design opportunities for developing more and better techniques for Shared Understanding. Insights on the mechanisms leading to Shared Understanding and the phenomenon itself, documented in the design principles, challenges and strategies, can serve as starting points for further thinkLet construction and theorizing on the clarify pattern. In particular, the potential of question-and-answer techniques for clarification should be explored. Furthermore, the role that (visual and haptic) boundary objects may play in the clarification process deserves consideration.

13 Practical Contributions of the Thesis

Success or failure of a group to increase their Shared Understanding in a collaborative situation used to depend strongly on the intuition of the collaboration process designer, the ability of a skillful facilitator, or was an unpredictable by-product of collaborative interaction. This thesis makes a contribution for practitioners faced with designing and executing collaborative work practices by providing the MindMerger compound thinkLet as a reusable building block for clarification (chapter 13.1). Furthermore, it contributes a full collaboration process design for knowledge integration (chapter 13.2) and field insights on common organizational knowledge management challenges (chapter 13.3).

13.1 The MindMerger compound thinkLet for Collaboration Engineering Practice

The central artifact and core contribution to Collaboration Engineering practice is the MindMerger compound thinkLet. The compound thinkLet has been developed iteratively throughout the action research project and has been validated with stable results on team learning, Shared Understanding, and team effectiveness in different task-team combinations within this work. Although further testing in more settings should be done to confirm external validity, current findings indicate that the MindMerger can be transferred to similar clarifying tasks. The technique can thus be used by designers of collaborative work practices as a building block to reliably evoke the construction of Shared Understanding in heterogeneous work groups. Especially for newly formed ad hoc teams, the MindMerger can be a means to build an initial Shared Understanding of the group task, increase team effectiveness and reduce late rework and iterative loops. In such, it complements the collection of thinkLets for other patterns of collaboration. In such, this thesis makes a contribution to Collaboration Engineering practice by filling a gap of techniques for the clarify pattern of collaboration (de Vreede et al. 2009).

13.2 A Collaboration Process Design for Knowledge Integration in Age and Experience Diverse Work Groups

On a more global level, the practical challenge identified in publication 3 is the integration of understanding in age and experience diverse groups. Techniques are required to support heterogeneous groups (be it ad hoc teams in distributed communities, experts of different profession in requirements negotiation processes or age diverse actors with knowledge transfer challenges) to become more efficient. The collaboration process design presented in publications 6 and 7 with the MindMerger instantiation as its core technique for clarification contributes a solution to this practical challenge for the specific setting in the action research pilot study. With the support of the collaboration process design, teams of age and experience diverse workers were able to increase their Shared Understanding on a complex work process and show high levels of team effectiveness and knowledge transfer after the three day workshop series. They were guided to produce high quality work process documentation in the form of learning material, which can be used to train new colleagues. Identification with their team and the results they achieved was high among the participants. Study results indicate that the process was successful in improving the set goal by improving knowledge integration and transfer among the participants. Therefore, the collaboration process design can serve as template for similar knowledge management challenges in other organizations.

13.3 Understanding of Organizational Knowledge Management Challenges

Building a Shared Understanding in heterogeneous groups is never an end at itself in organizational practice but a means to more effective collaboration of diverse members. In this work, I had the opportunity to get involved in a real world knowledge management challenge as it is common in many organizations. Findings on the interaction of experts and novices in collaborative knowledge transfer efforts from the action research investigation contribute to better understanding the challenges heterogeneous work groups face, the mechanisms they apply to integrate their knowledge, and the decisions that need to be addressed on a collaboration design or organizational knowledge management level. From the analysis of the action research pilot project with age and experience diverse tool and dye makers, I developed a collection of common challenges and solutions as well as critical incidents in a case study analysis. The implications from these observations can be used by designers of collaboration systems and organizational decision makers to better understand the patterns of successful and flawed knowledge transfer in their teams. Although only a starting point in the complex field of Shared Understanding and knowledge transfer in heterogeneous teams, this work can serve as a guideline for identifying similar or additional issues in comparable cases.

14 Limitations

This thesis is subject to a number of limitations, which are mainly related to the exploratory action research approach chosen, the complexity of the phenomenon of interest – Shared Understanding – and the available data for evaluation.

As discussed in section 4, action research is characterized by a close linkage of problem solving and research investigations. Due to this dual goal, in the central action research intervention in an organizational knowledge transfer pilot project, complex real world conditions had to be handled. Many external factors were determined by the real world problem situation (e.g. team staffing, group tasks etc.) and could not be completely controlled or measured for their influence on team interaction and Shared Understanding. Therefore, the MindMerger compound thinkLet could only be evaluated within these restrictions in that setting. As no control group without the MindMerger intervention was available and alternative influences on team learning behaviors and Shared Understanding could not be controlled for, observed effects in this study can only be interpreted in light of action research scope. Insights from this study are rich for the case at hand, but their transferability to other settings needs to be shown in further research. As the results have been stable between the action research cycles, the compound thinkLet has additionally been tested under experimental conditions with a different kind of clarification task, and the MindMerger design was theory driven, high external validity can nevertheless be assumed. Triangulation of date collection methods and evaluation approaches was used to minimize the limitations of action research (McKay and Marshall 2001).

The complexity of Shared Understanding as the phenomenon of interest is related to further limitations. First of all, it has to be noted that this thesis could not rely on a comprehensive and homogeneous literature base concerning the conceptualization and measurement of Shared Understanding. Advancing conceptualization and measurement are major contributions of this exploratory work as described in section 12. Therefore, both were by design subject to change throughout the action research investigation. In particular, I came to the conclusion that a combination of qualitative and quantitative, observational, self-reported and document-based measurement is needed. Not all data sources are accessible in all settings and still more research is needed on which measurement instruments reflect best the core idea of the multifaceted construct Shared Understanding, as it is defined in this work.

15 Implications for Future Research

The insights from this work help to identify future potential in the field of Shared Understanding research and provide starting points for further research. The following areas deserve special attention in follow up investigations. On the one hand, the understanding of the phenomenon Shared Understanding still needs to be advanced concerning the causal model for Shared Understanding construction (chapter 15.1) as well as the measurement techniques used (chapter 15.2). On the other hand, the MindMerger compound thinkLet deserves validation in alternative applications to unfold its full potential (chapter 15.3) and more clarification techniques should be developed (chapter 15.4).

15.1 Further Elaboration of a Causal Model for Shared Understanding

Findings from this thesis indicate that the development of Shared Understanding is a complex process. Although I found evidence that van den Bossche etl al. (2011)'s model of team learning behaviors is helpful to explain and predict the influence of three specific team interaction mechanisms on Shared Understanding and team effectiveness, a more comprehensive theoretical model would be helpful for behavioral as well as design research. In particular, further potential determinants of Shared Understanding that are discussed in literature should be integrated into the model. Some of these antecedents, such as reflecting behavior or the interaction with boundary objects, might be suitable to base design choices on, if a positive influence on Shared Understanding can be supported by future studies. Furthermore, moderating effects of different team constellations (e.g. different degrees of heterogeneity) or different types of group tasks (standardized vs. complex) should be investigated. In the settings at hand, teams and tasks were taken as given (in the action research project due to organizational restrictions) or assigned randomly to produce controlled experimental conditions. For organizational practice, theoretical knowledge would be of interest, how team and task characteristics interrelate with Shared Understanding construction. Finally, future research should analyze the relationship of Shared Understanding and team effectiveness in the light of the assumption that there might be an optimal degree of Shared Understanding for certain tasks that should not be exceeded to maximize team effectiveness. It should be investigated, whether too much overlap in understanding might even hinder team effectiveness e.g. for highly creative group tasks.

15.2 Advanced Measurement of Shared Understanding

Within this thesis, I have encountered a need for convergence on more systematic and comprehensive measurement of Shared Understanding. No widely used validated measurement instruments were available from literature. Therefore I used a combination of self-reported measures and analysis of the individuals' and teams' documents as proposed e.g. by van den Bossche et al. (2011). I found limitations in both measurement approaches. In particular, future research should test in representative studies, whether different approaches to measure Shared Understanding are equally suited to reflect the level of Shared Understanding. From the results of this thesis, I propose the assumption that self assessment seems to work well for evaluating one's own understanding and knowledge on a specific topic of understanding. However, assessing the knowledge of new team partners or the overlap of understanding within a team seemed difficult for the participants in my studies. Alternative measures should be developed to collect pre-task values for Shared Understanding in settings where no initial mental model representations can be generated. In some cases, it might be useful to execute an individual knowledge test with participants prior to collaborative work with questions on the object of understanding. In general, document analysis of mental model representations seemed to be more accurately reflecting the construct Shared Understanding in the explorations within this work. However, I analyzed only mental model visualizations on the group task as the object of understanding. Furthermore, document analysis could only cover the terms and relationships participants explicated voluntarily. Therefore, future investigations should focus on suitable representation forms for Shared Understanding on other objects, e.g. the group or the collaboration process. They should furthermore consider how to ensure a maximum degree of explication of participants' mental models.

15.3 Application of the MindMerger compound thinkLet to Related Domains

As thinkLets are documented and validated best practice techniques for evoking a specific pattern of collaboration, their validity depends strongly on their ability to evoke that pattern in a broad variety of applications. The same requirement of validation applies to the MindMerger compound thinkLet, as it promises to reliably increase Shared Understanding within groups. Within this thesis, implementation of the MindMerger in three different settings is described to demonstrate its applicability to requirements negotiation of diverse academic experts, knowledge integration of age and experience diverse craftsmen, and collaborative modelling of IS students. Future studies should aim to extend the validated scope of the MindMerger and point out potentials for designers of collaboration systems to improve clarification in other domains. As the overlap of literature and the exploratory findings of this study suggest, learning is closely related to Shared Understanding construction. The MindMerger might thus be a suitable technique to support clarification in collaborative teaching and learning concepts. Moreover, the MindMerger validation so far has been limited to same place same time paper based workshop settings with a facilitator. As the compound thinkLet is described independent of collaboration technology support, the design can be implemented in any group support system that allows for executing the defined activities. Future studies should try to transfer the MindMerger to computer supported workshop settings to potentially increase efficiency and reduce the facilitator's load. Clarification is a crucial challenge even in distributed virtual teams. If the MindMerger can be proven to increase Shared Understanding even in settings, where no personal interaction is possible, it would be a powerful tool for online collaboration e.g. collaboration platforms or organizational knowledge integration across different sites.

15.4 Development of Further Clarification Techniques

The results from designing and evaluating the MindMerger compound thinkLet provide evidence that the clarify pattern of collaboration can be deliberately evoked by collaboration design. These findings indicate that future Collaboration Engineering research should make use of the mechanisms explored in this study and the design approach and guidelines provided to develop more techniques for Shared Understanding. To build a comprehensive catalogue of clarification techniques, as it is available for other patterns of collaboration, additional thinkLets are needed for cases where the MindMerger is not applicable. For example, clarification in large groups, where the one-on-one interaction of the MindMerger is not suitable to create Shared Understanding within the whole group, deserves alternative techniques. Moreover, for objects of understanding that are too extensive to be visualized in one clear document to work with, other thinkLets for clarification might be needed. The proposed thinkLet design efforts can be guided by the same team learning behaviors used in this thesis (van den Bossche et al. 2011). The design guidelines presented in publication 2 (Bittner and Leimeister 2013) can be used to systematically search for more techniques that aim at evoking the team learning behaviors. Furthermore, other assumed antecedents to Shared Understanding could be used as levers to increase Shared

Understanding within groups. Researchers can find potential starting points for design in the conceptualization efforts provided in this thesis. The process to derive design guidelines from an initial theoretical framework, develop and test a collaboration technique in an iterative action research project can be executed accordingly.

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Ein gemeinsames Verständnis – Shared Understanding (SU) – gilt als zentrale Voraussetzung für die effektive Zusammenarbeit heterogener Arbeitsgruppen, jedoch mangelt es bisher in Forschung und Praxis an einem einheitlichem Verständnis der Determinanten sowie an Gestaltungswissen zum gezielten Hervorrufen von SU in Zusammenarbeitsprozessen. Diese Dissertation adressiert diese Lücke durch folgende Kernbeiträge:

- Konzeptionalisierung von Shared Understanding und seiner Determinanten
- Wiederverwendbare, validierte kollaborative Arbeitstechnik in Form des „MindMerger" compound thinkLet zur Bildung von SU
- Kollaborationsprozess für Wissenstransfer in heterogenen Arbeitsgruppen, iterativ entwickelt und erprobt in einem realweltlichen Aktionsforschungsprojekt

Das MindMerger compound thinkLet kann von Designern von Kollaborationsprozessen eingesetzt werden, um Klärungsprozesse in heterogenen Gruppen systematisch zu unterstützen, die Gruppenzusammenarbeit zu verbessern und dadurch die Gruppenleistung zu erhöhen. Daneben leistet diese Arbeit durch die Dokumentation von Kollaborationsprozessdesigns, Designrichtlinien und Vorgehensweisen Beiträge zur Weiterentwicklung der Gestaltungstheorie für SU im Feld Collaboration Engineering.

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