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Knowledge Integration in Face-to-Face Communication and the Moderating Effect of a Collaborative Visualization Tool

by

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Abstract

This paper sheds light on the communication process through which experts and decision makers integrate their domain specific knowledge in decision making situations and argues for the benefit of software-supported visualization of contributions. Understanding both decision making and knowledge integration as communicative processes, we present a short review of literature on the concept of knowledge integration. Based on this review, we present a model for knowledge integration and discuss an experimental study which provides a first empirical evaluation of the model. In the proposed model, knowledge integration is reflected by the resolution of four conversational challenges – equal participation, big picture thinking, establishing common ground, and constructive conflict. We argue that the modality of the conversation impacts on the importance of the single elements of knowledge integration. We show that – when supporting conversations with an interactive visualization tool –- conversation partners rely more on the construction of the big picture and of the common ground, and less on conflict and equal participation. Furthermore, the handling of conflict is more constructive than in the non-supported situation. An experimental study tests and confirms both the model for knowledge integration and the moderation effect of the use of the interactive visual tool.

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Introduction and Background

In the last decades knowledge has become ever more specialized and distributed. The distribution of expertise has profound implications for the coordination and integration mechanisms across knowledge boundaries (Brusoni *et al.*, 2001; Grant, 1996a). In decision making, in order to cope with the uncertainties of fast changing market environments and with the growing complexity of (organizational) problems and solutions, decision makers gather specialists from various domains pertinent to the decision to take. This paper focuses on how specialized knowledge is integrated in decision making, by analyzing the communications between domain experts and decision makers. It aims, on the one hand, to elicit crucial communicative challenges that arise when aiming to integrate specialized knowledge. In doing so, we approach knowledge integration from a *communicative perspective* and present a reflective model for knowledge integration. A second aim of the paper is to discuss the role of *collaborative visual software* tools in supporting the integration of knowledge in decision making. We present a first empirical evaluation of both the model for knowledge integration and the impact of the use of a collaborative visual tool on the basis of a class experiment.

A communicative perspective on knowledge is based on the belief that human knowledge is developed, created and integrated in social interaction (Berger & Luckman, 1966; Nonaka & Takeuchi, 1995) and that communication is the main form of how people interact with each other. In this way, we can understand knowledge processes to be communication processes. As a consequence, studying communicative patterns, practices, and challenges sharpens the understanding of the way people create and integrate knowledge. A communicative perspective as we pursue it – that is focusing on co-located, face-to-face conversations – does not focus on macro aspects of the knowledge integration process. The integration of specialized knowledge in decision making is bound to a variety of organizational and political constellations (Eisenhardt & Zbaracki, 1992; Swan & Scarbrough, 2005). Power struggles and the pursuit of personal interests might even lead to instances in which specialized knowledge is either deliberately not considered, or only said to be taken into account.

There are specific requirements for conversations apt to integrate knowledge in decision making. The aim of knowledge integration is to maintain or even foster a functional degree of specialization, while being able to combine and apply this highly specialized knowledge into joint actions and decisions (Eisenhardt & Santos, 2000). This is in contrast to a logic

of knowledge 'transfer' (Szulanski, 2000) where knowledge gaps should be minimized. As such, knowledge integration requires the synthesis of individuals' disparate specialized knowledge into situation-specific systemic knowledge without extensive communication or transfer of that knowledge (Alavi & Tiwana, 2002: 1031; Grant, 1996a). In addition, the creation of new meaning and knowledge is intrinsic to the process of knowledge integration. When interacting, the insights of various specialists are combined and "generated in" a new context and are not to simply exchanged or transferred (Cook & Brown, 1999: 388). As a consequence, knowledge integration requires synthetic modes of communication, which yet can represent in an adequate manner the complexity of the issue of decision. Also, integration requires modes of communication, which allow for transcending the knowledge boundaries that exist among communication partners. The concept of 'knowledge boundary' refers to the idea that people with in-depth expertise in different fields talk different languages, interpret same events differently, do not share the same values and interests and are immersed in specific practices (Carlile, 2002). These differences demarcate boundaries across areas of specialization and make the communication and integration of knowledge difficult. The communicative mode needs to allow for the development of a shared understanding and for the 'generation' of a new meaning among the interlocutors.

In the following, we will focus on a specific type of communication, co-located face-to-face conversations and discuss the role of collaborative visual tools that facilitate the integration of specialized knowledge in decision making. Conversations are especially suited to meet the above mentioned challenges as they allow for the co-construction of meaning and are a typical way in which members of an organization engage in sense-making (Weick, 1979). Conversations offer various analytical advantages for decision making. They are highly interactive and iterative; participants can ask clarifying questions, deepen certain aspects, and ask for the larger context of a specific piece of information. In conversations, the participants have the opportunity to adapt their language and the complexity of discourse to the characteristics of their vis-à-vis, and can continuously readjust their mode of communication when perceiving a specific verbal and non-verbal feedback of their communication partners (Krauss & Fussell, 1991). All these are important aspects for overcoming knowledge boundaries. In addition, articulating and summarizing information is another important process in sense-making (Dixon, 1997) and the integration of knowledge. Conversations also create a shared experience (Dixon, 1997); they build trust and strengthen the relationships between the participants (Harkins, 1999). For all these characteristics of conversations, it is a preferred communication form for knowledge integration in groups for decision making processes. Von Krogh, Ijicho, and

Nonaka (2000) argue that “good conversations are the cradle of social knowledge in any organization” as they allow for the sharing of tacit knowledge within a micro community (von Krogh et al., 2000, p.125) and for the externalization of tacit knowledge (Nonaka & Takeuchi, 1995) through a collaborative development of a common language.

In spite of the centrality of conversations for the process of knowledge integration, there are a variety of *challenges* that are present when integrating knowledge in conversations: A first set of challenges is related to routine conversational practices, which can be observed in a variety of conversational situations, but are particularly problematic for knowledge integration. Examples are defensive arguing (Argyris, 1996), unequal turn-talking (Ellinor & Gerard, 1998), or dichotomous arguing (Tannen, 1999). These patterns are based on cognitive and socio-psychological processes and tendencies like face-threatening or face-saving behavior (Slugoski & Turnbull, 1988), poor analogical reasoning (Thompson, 2000), in-group favoritism (Brewer, 1979; Messick & Mackie, 1989), and groupthink (Janis & Mann, 1977). Such difficulties might be aggravated if there are strong differences in perspectives between the conversation partners (due to educational background, professional experiences, cultural orientations, gender, social context, plans, goals, and other factors more) as is often the case in the expert-decision maker interaction.

A second set of challenges for the integration of knowledge is bound to the communicational form of conversations as such. Conversations are ephemeral and non-persistent (Bregman & Haythornthwaite, 2001) and the attempts to intelligently retain the content of conversations are still in their early stages. The decisive reasons and motivations behind the decisions taken are therefore often poorly documented. Conversations can take place in a co-located form only if participants are physically present. If people are geographically dispersed, non-verbal signs that provide important further cues for sense-making, can still be communicated (over streaming and video devices), but the deep and trustful relationships needed for knowledge integration are more difficult to develop (Chidambaram, 1996). Finally, conversations are essentially temporal, both in terms of the progression of the single speech acts as also in their wider context within a community or organization (Flores *et al.*, 1988). This is a limitation when people need to combine, compare, and evaluate large amounts of information items, all activities central to decision making in complex environments.

In view of the centrality, but also limitations of conversations for the integration of knowledge in decision making, the question whether collaborative visualization software can support conversers in their knowledge integration attempts, is an important one. Based on the

literature, we will argue that visuals – used in complementary to the verbal language - offer various advantages in overcoming knowledge boundaries as they provide a shared resource and external referent for creating common ground (Carlile, 2002). The visual language encourages analogies and makes abstract thought more tangible (Inns, 2002; Kraut *et al.*, 2003). These are all aspects which are important to create shared understanding. The semantics and syntax of visuals are looser defined than those of verbal language, which makes it easier to grasp something that is difficult to put into words (e.g. expressing tacit knowledge). As the visual is used in combination with talk, the discussion about its meaning can surface potential misunderstanding or ambiguities. This clarification process leads to a gradual development of common ground. We will also argue that images have an integrative capacity, as the various elements of which they are composed are visually related to one another. In this way, visuals help to maintain the big picture of a complex issue (Dimond & Beaumont, 1974; Kosslyn, 1978; Maruyama, 1986).

The remainder of this paper is structured as follows. By referring to the relevant literature on knowledge integration and through three explorative case studies, we will present a reflective model for knowledge integration. We then discuss the moderating effect of the use of collaborative visual tools for knowledge integration. In other words, we claim that although the proposed model is valid for knowledge-integrating conversations in general, the weight of its single components – equal participation, big picture, common ground, constructive conflict - varies depending on the modality of the conversation. Following this argument, we examine more specifically if some challenges of knowledge integration become more (less) important when supporting face-to-face conversations through interactive visualization. We formulate the hypotheses that, in the natural condition, because of a lack of common ground and the difficulty to create a big picture, conversation partners compensate with conflict, which threatens knowledge integration. We then present a comparative study using of a class-room experiment, which serves as a first empirical test of the proposed model of knowledge integration and of the moderation effect of the group decision support tool.

A Communicative Model for Knowledge Integration in Decision Making

Differentiation and the consequent need for integration and coordination is a classical theme in organizational studies (Galbraith, 1995; Lawrence & Lorsch, 1967). With the more recent discussion on expertise and knowledge as key resources of organizations (Grant,

1996b), the discourse on specialization and integration has started to be led more specifically with regard to knowledge. Grant describes this idea as follows:

> "If knowledge is a critical input into all production processes, if efficiency requires that it is created and stored by individuals in specialized form, and if production requires the application of many types of specialized knowledge, then the primary role of the firm is the *integration of knowledge*" (Grant, 1996a: 377).

Organizations that aim to create complex products or services, solve multifaceted problems, and make decisions in uncertain environments, they need to manage and facilitate the *collaboration* of people with *different* expertise and specializations. In view of the centrality of knowledge integration for the organizational activity, a still rather small but growing community of scholars started to focus on this particular knowledge process (Alavi & Tiwana, 2002; Bechky, 2003; Carlile, 2004; Carlile & Rebentisch, 2003; Dougherty, 1992; Eisenhardt & Santos, 2000; Grant, 1996a). While the discourse on knowledge integration is based on the premise that there is a simultaneous need for a specialization of knowledge and for coordination among specialized knowledge areas, various understandings and approaches can be identified. Knowledge integration can be understood on an *individual* (Davis, 2003; Linn *et al.*, 2003; Linn *et al.*, 2004; Linn & Hsi, 2000) or on a *social level* (Alavi & Tiwana, 2002; Grant, 1996a; Huang & Newell, 2003; Okhuysen & Eisenhardt, 2002).

Many authors implicitly or explicitly relate the concept of knowledge integration to the one of transfer. While some use the two words interchangeably, other authors insist on important distinctions between the two knowledge processes. Some claim that both transfer and integration models are valuable depending on the requirements determined by the situation of the organization and of its environment. Carlile and Rebentisch, for example, say that, first, depending on the amount of *novelty* arisen in the environment between the moments when knowledge is stored and retrieved (fast changing versus stable environments) and, second, conditional upon how strongly the various sources of specialized knowledge *depend* on each other, either transfer or integration models are most adequate. When novelty and dependence are high, transfer models are insufficient and integration models, which envision transformation processes, are necessary (Carlile & Rebentisch, 2003). Others criticize knowledge transfer models even more generally and claim that these are mostly founded on a mechanical understanding of knowledge processes and on a conception of knowledge as an *object* rather than as an activity and practice (Cook & Brown, 1999). They argue that in the wide-spread *object-view* of knowledge (Argote & Ingram, 2000; Walsh & Ungson, 1991) should be replaced by a conceptualization of knowledge as a *part of action*, an *activity of knowing*. Knowledge is situ-

ated (Bechky, 2003) and bound to practice (Brown & Duguid, 2001), knowledge cannot be transferred, distributed, or disseminated, but has to be "generated in" other contexts, groups, or organizations (Cook & Brown, 1999, p.398). Knowledge always has to be actively constructed in a new context, it has to be transformed (Bechky, 2003; Carlile, 2004). Unlike knowledge transfer, the term 'knowledge integration' better accounts for the transformations involved in the interactions between people using "knowledge as a tool" (Cook & Brown, 1999, p.388).

Studies on knowledge integration differ with regard to how knowledge integration is conceptualized and at which unit it is analyzed. Knowledge integration can be understood on an individual (Davis, 2003; Linn *et al.*, 2003; Linn *et al.*, 2004; Linn & Hsi, 2000) or on a social level (Alavi & Tiwana, 2002; Grant, 1996a; Huang & Newell, 2003; Okhuysen & Eisenhardt, 2002).

Conceived as an *individual practice*, knowledge integration describes the process by which an individual integrates new information into his/her existing knowledge structure (Linn et al., 2004). The 'old' knowledge is not simply replaced by other ideas, neither is the new idea simply assimilated in the existing knowledge structure. Instead, knowledge integration takes place through a processes of interlinking, contextualizing, comparing, interpreting, and evaluating (Linn et al., 2003). All these processes are understood cognitively and researchers are interested in instructional designs that can enhance them (Davis, 2003, p. 23).

Understood as a *social process*, researchers are interested in how specialized individual knowledge is integrated into some sort of collective knowledge (Okhuysen & Eisenhardt, 2002). While some researchers focus on the *group level* of analysis (Alavi & Tiwana, 2002; Okhuysen & Eisenhardt, 2002; Piontkowski & Keil, 2004; Piontkowski *et al.*, 2004), others analyze the process on an *organizational level* (Bechky, 2003; Carlile, 2004; Carlile & Rebentisch, 2003; De Boer *et al.*, 1999; Eisenhardt & Santos, 2000; Grant, 1996a; Huang & Newell, 2003; Ravasi & Verona, 2001) and still others focus on knowledge integration *across organizations* (within networks of organizations) (Swan & Scarbrough, 2005).

On a *group* unit of analysis knowledge integration is defined as "the synthesis of individual's specialized knowledge into situation-specific systemic knowledge" (Alavi & Tiwana, 2002: 1030). Researchers in these context aim to understand how knowledge is integrated in and through communication and examine interaction patterns and media (e.g. online, face-to-face, knowledge management systems) (Alavi & Tiwana, 2002; Okhuysen & Eisenhardt, 2002; Piontkowski & Keil, 2004).

On an *organizational* level, the seminal work on knowledge integration is the one of Grant (1996a). In his view, knowledge integration is the incorporation of the individuals' specialized (mainly tacit but also explicit) knowledge into tasks and organizational action. The main integration mechanism is not communication, but are direction, organizational routines (Grant, 1996a), and self-contained tasks (Huang & Newell, 2003). Yet, both giving direction and installing routines requires a communication that is based on a sufficient common knowledge and a shared language (Grant, 1996a: 380). There's another group of researchers equally analyzing knowledge integration on an organizational level, but which places stronger emphasis on coordination and communication. By analyzing knowledge integration efforts across functional divisions (Carlile, 2002; Dougherty, 1992), between occupational groups (Bechky, 2003) or between projects and the organization as a whole (Scarbrough et al., 2004), they discuss how 'knowledge boundaries' (Star, 1989) develop across specialized areas of expertise and what challenges subsist by attempting to integrate knowledge across these boundaries. In view of the embedded nature of knowledge, knowledge integration requires a transformation process of meaning and of interests (Carlile, 2004), which is why it is fundamental to engage in boundary spanning activities. Such activities include the use of boundary objects (documents, forms, methods, objects, etc.) used by individuals and groups at both sides of a knowledge boundary, which help them "to specify and learn about their differences and dependencies" (Carlile, 2002: 452)) as well as the positioning of knowledge brokers (people who move between two knowledge domains and like to engage in processes of translation, coordination, and alignment between perspectives (Wenger, 1998)).

Finally, there are few contributions dealing with knowledge-integration on an *inter-organizational level*. For an organization to be innovative, the integration of external knowledge is fundamental (Swan & Scarbrough, 2005). Depending on the type of knowledge to be integrated, but also on the speed, with which such knowledge has to be integrated, the couplings between organizations must be of a different nature (Grant, 1996a). Grant argues that while market contracts might work if the knowledge is embedded in the product itself, networks with close relationships are useful if knowledge is ambiguous, uncertain, and tacit. Further, if companies gain important advantages from the speed of integration (dynamic environments), knowledge integration is preferred to happen in networks rather than through vertical integration. Swan and Scarbrough finally claim that if knowledge is particularly diverse among the various organizations (difference between knowledge sources), close ties and informal interactions are particularly important to establish the sufficient common ground (Swan & Scarbrough, 2005).

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In line with our previous argumentation and given our context of study, we conceptualize knowledge integration as a *social process* that takes place in interaction and not as an individual process (in which an individual integrates a new piece of information into his/her existing knowledge structures). Understood as a social process, some authors focus more on the integration of specialized individual knowledge into *(group) knowledge structures* (Alavi & Tiwana, 2002), or, alternatively, on the integration of knowledge into *action* (Grant, 1996a) *and decision making* processes (for a more elaborate distinction of these various approaches and understandings of knowledge integration, (see:Mengis & Eppler, 2005a)). In our view, it is fruitful to combine both perspectives and understand knowledge integration as an interrelated *two-phase-process*: A first phase of integration is the co-creation of the specialized knowledge of individuals into group knowledge structures. In a second phase, knowledge integration involves the application of the integrated knowledge within a group of experts and decision makers into the actual decision making process. The following model (see: **Fehler! Verweisquelle konnte nicht gefunden werden.**) reflects these two levels of the knowledge integration process.

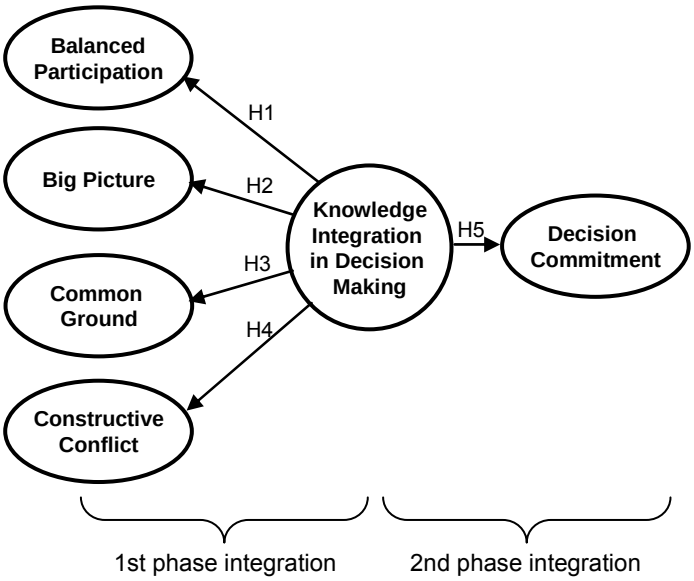

Figure 1: A Reflective Model for Knowledge Integration in Decision Making

We argue that if domain experts and decision makers manage to overcome four central communicative challenges, which are balanced participation, big picture, common ground, and constructive conflict, they are more likely successful in integrating their specialized, individual knowledge into synthetic common group knowledge structures (1st integration phase). Second, we stipulate that if specialized individual knowledge is successfully integrated in group knowledge (1st phase integration), a stronger decision commitment is the result. Decision commitment is an indicator for the integration of knowledge in action and decision making (2nd phase integration).

In this form, the model we present is an indirect reflective model with multiple mediating constructs (Edwards & Bagozzi, 2000). As a reflective model, the measures "represent reflections, or manifestations", of the construct and are not viewed as the causes of the construct (Edwards & Bagozzi, 2000: 155). We therefore would not say that knowledge integration is caused by equal participation, the establishment of a common ground and a big picture, and finally by the presence of a constructive construct. Rather, the conjoint manifestations of the said variables are reflections of the occurrence of knowledge integration. It is an indirect model insofar as the variables reflecting 'knowledge integration' are mediating variables that cannot be observed directly and 'knowledge integration' can be understood as a second order factor.

In the following, we will present the single order constructs of knowledge integration one by one. We do so by referring, on the one hand, to the insights we have gained from explorative case study work, and, on the other, to the existing communication and knowledge management literature.

Regarding the case study work, we have drawn on evidence from three case studies. Common criteria for the selection of the cases are that the duplet "domain experts – decision makers" must be easily identifiable, that the decision issue is complex and ambiguous, and that there is a strong motivation to integrate the specialized knowledge in the decision making process. The cases differ substantially in terms of type of knowledge to be integrated or whether the knowledge integration process takes place in an intra- or an inter-organizational context. We were explicitly looking for variances in the institutional context and the type of knowledge, so we could be more certain when we would attribute recurring communicative patterns that would emerge across the cases to the situation of knowledge asymmetry between experts and decision makers.

In the first case, we have looked at the integration of knowledge and the communication processes between the experts of a major U.S. think tank and the policy makers in the U.S. Senate. In the second case, we have analyzed the knowledge communication between IT specialists and the middle managers of a large financial institution. The third case examines the knowledge communication between domain specific consultants and their clients. For all cases, we have considered a multitude of sources. For each case we have conducted around eleven half-structured interviews, each of which lasted on average 45 minutes. We have interviewed mainly domain experts, but to a less extent also decision makers. We have transcribed the interviews and have engaged in a comparative coding activity to solicit patterns and categories from the interview data (Glaser, 1998). In addition and contingent on the particular situation of each case, we have conducted a qualitative analysis of communication outlets such as the web site, articles, reports, power point presentations, and meetings minutes (for a systematic and detailed documentation of the cases, see: www.knowledge-communication.org). From the cross-case analysis of the three cases, we were able to identify recurring communicative challenges and practices. From this analysis and by drawing on the literature on knowledge integration in decision making, we have developed the following model for knowledge integration. In the present article, we will use the evidence from the cases only in an explorative way to further motivate – next to the argumentation of the present literature – the choice of the elements of the here presented model for knowledge integration.

Equal Participation

Groups often fail to maximize the contribution of all members (Stasser & Stewart, 1992). Certain participants in a conversation, often subordinates, feel inhibited to expose their own ideas to management for fear of criticism (Dixon, 1997). In other instances, management has a rather autocratic style and does not actively seek for the contribution of others (Eisenhardt *et al.,* 2000). Unbalanced power structures lead to instances in which conversation partners participate in an unequal manner in the conversation process so that the various perspectives on an issue are not brought up and considered equally (Ellinor et al., 1998). A balanced participation of all conversation partners is an important pre-condition for knowledge integration.. In a situation in which not all participants of a conversation can participate in the collaborative co-construction of knowledge, the specialized knowledge of all members will not be integrated. Without the equal participation of all conversation partners, collaborative learning (Dixon, 1997) and knowledge integration are therefore impossible. In the interviews for the three explorative case studies, it has turned out clearly that both experts and decision makers are quite aware that an important part of their job is to actively incite the participation of the other party. They reported that only in this way they obtained the necessary information, they could get a feeling of the other's perspective, they could discover the hidden causes of a problem, and could prevent possible misunderstandings. Several referred to the necessity to be skilled in various techniques that permitted to elicit the necessary information. Also the literature stresses this aspect of balanced participation and various authors descriptively define effective knowledge-intensive conversation as interactions in which participants alternate their contributions in balanced ways and actively engage in participation and collaboration (Barge & Oliver, 2003; Beer & Eisenstat, 2004; Dixon, 1997; Eisenhardt et al., 2000; Ellinor & Gerard, 1998; von Krogh et al., 2000). We claim that:

H1: the equal participation of all participants in a conversation positively reflects the process of knowledge integration.

Big Picture

Gaining and sustaining the big picture is a particularly difficult challenge of the expert-decision maker interaction and an important indicator of knowledge integration. During the case interviews, experts and decision makers mentioned frequently that a major difficulty of their interactions is not to loose track of the overarching thread of an issue, but to integrate

their various points of view and the range of pertinent aspects in order to finally understand how these different elements interrelate with each other and form an integrative whole. They often had the feeling of being stuck in a sea of technical details of which they did not know how they related to the more general issue that was the object of decision. Experts and decision makers have to struggle quite a bit to bring their various highly specialized perspectives together and to build a more profound and shared understanding of the issue that is object of decision. Taken the arguments together that emerged in the interviews, it seems that the big-picture challenge is related to the capacity to see and draw *interconnections* and to find an adequate *level of detail/abstraction.* We define the big picture challenge as the difficulty to gain and keep an adequate overview of a complex issue by identifying its main drivers and the interconnections among them, while paying sufficient attention to its relevant details.

Experts and decision makers have to see the *interconnections* between the various perspectives they bring into the discussion, between the punctuated issue on which they have to decide and the larger context in which it is embedded (e.g. related issues). Experts and decision makers have a very specific view on the issue and often are not able to envision the big picture of a solution or decision on their own, but have to integrate both perspectives. In this situation, the challenge is to be open enough for another perspective and to see the interconnections among the different perspectives and points of view. Second, experts and decision makers have to understand how a specific technical aspect that an expert mentions relates to the more general discourse of the issue. Harkins defines "big-picture thinking" as the "ability to conceptualize underlying or systemic causes driving a problem or issue" (Harkins, 1999: 34). In this light, the capability to gain and maintain the big picture is strongly related to the ability of systemic thinking. Senge advocates that while traditional analysis focuses on separating out different pieces, the holistic perspective of the systems thinking approach focuses on how things are interrelated and how they form an overall system (Senge, 1990). The challenge is to connect isolated pieces into recursive causal chains and to develop a more dynamic view of a system.[1]

[1] In the realm of systemic thinking, the big picture challenge has been discussed mainly as an individual challenge and not as a social and communicative one as proposed here. Other authors who conceived this problem on an individual level, have further argued that certain cognitive styles (e.g. the 'imaginist') are better suited to see the big picture than others (Graetz, 2002). While for them, the capacity to see the big picture is innate and stable for a person, Gasper and Clore have shown, in contrast, that the individuals' mood impacts on his/her

Next and related to the issue of interconnections, the big picture problem is also about the adequate *level of detail or abstraction.* Too much detail leads to disorientation (how does the detail relate to the more general issue?) and a feeling of a loss of time and of a lack of pertinence. It has been argued that "creative processes involve first envisioning 'the big picture' and then working out the details at a later stage. A sculptor, for example, starts by carving out a rough outline and then progressively adds finer detail" (Ringach, 2003: 7). Yet, in many cases, experts and decision makers cannot simply adopt such "a top-down (or coarse-to-fine) method" (Ringach, 2003: 7), but "the big picture is formed by small details" so that the challenge is not simply to understand the big threads of an issue, but also the small details of which they are made (Sull *et al.*, 2005: 37). Providing details is often necessary to understand a more abstract concept, to see the implications of an issue, and to comprehend whether or not a certain solution is feasible. Rhodes argues on this purpose that "one of the most common reasons for being off the mark is operating on the wrong level or scale" (Rhodes, 1991: 162-163) and not marking clearly on which level of detail one is operating. It is not self-evident to judge upon the importance and pertinence of a piece of information and to determine the adequate level of detail. Experts, with their very domain specific, but profound knowledge (Hoffman *et al.*, 1995), perceive something as still quite abrasive and superficial while for the decision makers it is already extremely specific and too rich in detail.

With regard to the interconnectivity-capacity and the level of detail/abstraction, we can understand the big picture challenge as related to the *issue* upon which decision makers have to decide and for which they ask for the experts' advise. Alternatively, we can understand the problem as related to the *process of the conversation* itself. The interconnection issue, for example, refers to the challenge to see the links among the causes of an *issue*, or between the causes and their symptoms. But the interconnection issue can refer, also, to the challenge to draw the connection between what X said five minutes ago and what Y said just a moment ago and whether there are explicit links among the single contributions or phases in a conversation, which facilitates the creation of the bigger picture. We believe that the big picture of the issue and the big picture of the conversation process are very much interlinked so that a more explicit structure of the conversation process also facilitates to gain the big picture on the issue. In a conversation, in which it is clear how a certain statement relates to another and on which level of abstraction one is moving, it is also easier to understand how a certain technical detail

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capacity to see the big picture; if people are happy, they tend to be more oriented on the forest, if they are sad they merely look at the trees (Gasper & Clore, 2002).

of the problem refers to one of its more general drivers. In order to keep the 'big picture' construct as clean as possible and not to mix it up with the other constructs of our model, we focus entirely on the process level of the conversation process itself. We claim that:

H2: successfully coping with the big picture challenge positively reflects the process of knowledge integration.

Common Ground

Alavi and Tiwana argued that 'mutual understanding' or mutual knowledge – understood as the knowledge that is shared among people and that is known to be shared - represents one of the key challenges of knowledge integration. They say that "it lies at the intersection of the specialized knowledge sets that a virtual organization must integrate" (Alavi & Tiwana, 2002: 1033). Similarly, Carlile (2004)and also Bechky (2003) refer to the importance of 'common knowledge' or 'common ground' for managing knowledge integration across boundaries. In communication theory, this is best known as the 'common ground' challenge, as proposed by Clark and his colleagues (Clark, 1996; Clark & Brennan, 1991; Clark & Marshall, 1981). Common ground is defined by the context conversation partners can reasonably assume to be sharing among them. It includes their background knowledge, beliefs, current interpretations, goals, values, but also their social and physical context and more personal attributes as speech style or emotional state (Krauss & Fussell, 1991). It is said that communication is more efficient and productive when people share greater amounts of common ground (Olson & Olson, 2000). At least, participants of a conversation need to share a minimal common ground in order to understand each other and to take informed decisions. Fahey and Prusak outline for example: "In the absence of shared context, individuals' differing perspectives, beliefs, assumptions, and views of the future are most likely to collide and thus immobilize decision making" (1998: 258). They believe that without the needed shared context, people will not reach a deeper understanding through dialogue and will not be able to traverse the difficult path from information to knowledge and neither from knowledge to decision making. A related concept to the one of common ground is "ba", which has been introduced by Nonaka and his colleagues. They understand "ba" as a shared physical, virtual, and mental space, "a 'phenomenal' place" (Nonaka & Konno, 1998: 41), which is necessary in order to create new knowledge. Although the concept of "ba" is larger than the one of common ground, it stresses the same idea that, in order to engage in processes such as knowledge creation or knowledge integration, it is necessary to share a certain common space, in which the knowledge to be

integrated can be embedded. It is a space that involves shared experiences, ideas, values, but also common physical and virtual rooms, which include artifacts and universes of meaning.

Interaction partners engage in grounding (activities to build common ground) by using the sources of community membership, linguistic co-presence, and physical co-presence (Clark & Marshall, 1981). If people know that they belong to a same group or population, they can assume that the peculiarities of this group can be considered to be common ground (community membership). Second, if they had prior interactions (linguistic co-presence), they then have established certain aspects and relations to be common ground (they have agreed in earlier communications that when X is true then Y). Finally, if they share the same physical setting (physical co-presence), they can use it in the form of deictic speech (by pointing and using words like 'that' or 'here') and non-verbal communication (e.g. gestures) to build common ground (Clark & Marshall, 1981).

In the expert-decision maker situation, these sources of common ground are often sparse; communication partners do not belong to the same professional community and have a few knowledge on the peculiarities of the other community, they have few interactions with each other (lack of linguistic co-presence), and communicate in written formats (lack of physical co-presence). In fact, many interviewees of the here reported case studies referred to the common ground challenge: Experts, when preparing their reports or presentations, often have difficulties in assessing the decision makers' knowledge and even in evaluating their own knowledge in relation to the others: What should they expose that is valuable to the decision makers? What can they take for granted? The common ground challenge also comes to play when experts and decision makers have to deal with implicit misunderstandings. They are often unaware of using specific terms (e.g. process management) in a completely different way (e.g. as a management versus a support process) and realize that they have misunderstood each other only much later. This can lead to considerable consequences such as late redefinition of project scopes and consequent project delays. The fact that experts and decision makers use language differently implies not only that they have different understandings of terms, but includes also different ways of expression, the use of different jargon, and other conventional features (differences in phonology, morphology, syntax, semantics, and pragmatics (Clark, 1996)). It turned out several times in the interviews that underlain to language, experts and decision makers have quite different perspectives and modes of thinking, which makes a shared understanding quite challenging. While economic experts, for example, are inclined thinking that when 'all else being equal, the partial equation of changing this is changing that',

policy makers often infer from the concomitance of two events that they must be casually interrelated. Interviewees reported throughout the various case situations that if the lack of common ground is very apparent (for example if the expert's knowledge is very specific and technical or if experts and decision makers interact for the first times), it is particularly important to interact frequently, meeting physically and informally, and rely on face-to-face conversations.

The concept of "common ground" comprises not only the idea that the communication partners share a common understanding of an issue and a joint vision of what they are aiming to achieve. As the first examples from the case studies have shown, it also means that the experts and decision makers have a sense of the reciprocal knowledge and perspectives. This latter aspect of the common ground – to have a sense of what knowledge is shared among experts and decision makers and what is unique to each party - is similar to the concept of transactive memory to which we have referred earlier on. Only with a sufficient common ground, the communicator is able to adjust his/her messages to the receiver, what does he know and what doesn't he, and what level of complexity will be suited to assure his/her understanding? Krauss and Fussell call this activity 'reciprocal perspective-taking', in which one tries to experience the situation as it is lived by others and adapt the content and form of the message to it (1998). The reciprocal perspective-taking is an important aspect in forming common ground among communicators. If it lacks, people ultimately have to draw on their knowledge of the more general social categories to which their vis-à-vis belongs (e.g. car fan, engineer, New Yorker) and from which they can induce certain general characteristics (Clark, 1996; Krauss & Fussell, 1998). As the conversation partners go on in the interaction, they receive continuous verbal, para-verbal, and non verbal feedback and this additional information allows them for gradually fine-tuning their assumptions of the perspectives and information needs of the others (Krauss & Fussell, 1998; Schober & Clark, 1989). In this way, the more the experts and decision makers interact, the more they establish a common ground between them, and the better they can adjust their mode of interaction. Conversations are a communicational form that allows participants for sharing experiences and therewith is especially important in creating 'personal common ground' (Clark, 1996). Common experiences are "powerful sources of shared meaning because it is possible to reference the experience and thus to bring to mind for everyone a meaningful image" (Dixon, 1997: 32).

The critical reader might legitimately ask if there is not an apparent contradiction between the here proclaimed necessity of a common ground, on the one hand, and, on the other

hand, the growing necessity for strong specialization of functions and roles (it is the very scope of experts and decision makers to have different perspectives, backgrounds, priorities)? Deetz, for example, describes the sustaining of differences (and the therewith going creativity) as an altogether opposite objective of dialogue than aiming for common ground and value consensus (Heath *et al.*, 2006). Similarly, Dyer and Nobeoka could show in a different context (they analyzed the sharing of knowledge on a company network level) that "strong ties" (i.e. a lot of common ground) are well suited for the diffusion (exploitation) of existing knowledge rather than for the exploration of new knowledge, which is the strength of "weak ties"-relations (Dyer & Nobeoka, 2000: 364/365). Translated to the context of experts and decision makers, this means that strong ties and a lot of common ground would lead mainly to status quo-oriented decisions, which are rather problematic in complex, ambiguous, high-velocity environments. We see this apparent stretch between common ground and specialization not as dualisms, but as dualities. The common ground challenge really is a question of balance. Too much common ground would turn the separation of the expert and decision maker roles obsolete, too less common ground would turn their communication extremely difficult if not impossible. The aim in the collaboration of experts and decision makers therefore must be to assure a necessary common ground, but not to have too large overlaps. For groups who have just been formed, as is the case of the experimental setting of this study, the risk to have too much common ground and not enough specialization is relatively small. We claim that:

H3: establishing a common ground among the conversation partners positively reflects the process of knowledge integration.

Constructive Conflict

Conflict of some form has been a recurring issue in the interviews for the explorative case studies. Conflict often is *relational* and the interviewers referred to it, for example, as the decision makers' general suspicion towards the expertise of the domain experts. Conflict also takes the form of reciprocal negative prejudices (e.g. experts believe that the decision makers will never be able to understand the engineering aspects the decision involves), of lacking trust, and of the fear for loosing face and therefore pretending to know or refusing to get to know more. Decision makers are quite naturally inclined to thinking that they hold their leading role because they have the necessary experience and knowledge. It is therefore not an easy task form them to admit their ignorance in front of a domain expert and to embrace the knowledge that is offered to him/her. Yet, conflict arises not only because of relational issues. It is

also bound to disagreements and differences in perspective with regard to the *task* and content of the decision. Experts and decision makers tend to weight issues differently and have different time horizons. The proposition of accurate, thorough solutions might stand in conflict to the decision maker's need for pragmatic, quick fixes. The focus on more systemic, integrated views might be counterintuitive for someone who is used to think at one thing at a time. The interviewers reported that such differences in orientation often required long discussions in order to achieve a shared understanding.

The subdivision of conflict into relationship and task conflict was proposed by Jehn (1995), who basically made two claims when proposing this distinction. On the one hand, *relationship conflict* – understood as an emotional conflict and a perception of an interpersonal incompatibility - is detrimental for team effectiveness, decision quality, and decision commitment. People feel stressed and anxious and they perceive the conflict as a threat to their identity and their feelings of self worth (Jehn & Mannix, 2001). In such a situation, people are hesitant to expose their ideas, to inquire collaboratively into new solutions, and to integrate their knowledge. Jehn and Mannix (2001) argue that their ability to process information is reduced since they spend most of their energy focusing on each other. For these reasons, relationship conflict negatively reflects knowledge integration.

On the other hand, *task conflict* – a perception of disagreements (in terms of viewpoints, ideas, opinions) regarding the content of a decision - can have important positive effects (Jehn, 1995). Advantages of task conflict are that people scrutinize task issues and engage in a deep and deliberate processing of the available information. It encourages a greater cognitive understanding of the issue (and therefore leads to a better decision quality). Finally, it fosters learning, the development of innovative insights, and a stronger decision commitment (Simons & Peterson, 2000). These are all important aspects for the process of knowledge integration. Similarly, Eisenhardt and her colleagues argue that task conflict is important for developing a more complete understanding of the choices and for creating a richer range of options (Eisenhardt et al., 2000: 77). Finally, task conflict is said to foster innovation because it makes people consider the perspectives of others and create new understandings of apparently known issues (De Dreu, 1997). Yet, a very strong task conflict is said to have negative effects on member satisfaction, or on the commitment to the team and decision (Amason, 1996; Simons & Peterson, 2000). People feel frustrated when some people continuously take their chance to disagree and oppose and therewith delay the decision (Peterson, 1999). Similarly, we argue that in presence of a too high level of task conflict, conversation partners have

difficulties in integrating knowledge. If the perspectives, points of view, and opinions are very far away from each other, tough content based argumentations are not reflecting a real integration of knowledge. People will continue to believe their point of view. They might acknowledge the opposite opinion to have a reason of existence, but remain far from seriously considering it for the further development of their own point of view. We will therefore stipulate that the relationship of task conflict and knowledge integration is one of an inverted U-curve: in the presence of a low or very high level of task conflict, knowledge is not integrated (see: *Figure 2*). A moderate level of task conflict best reflects knowledge integration.

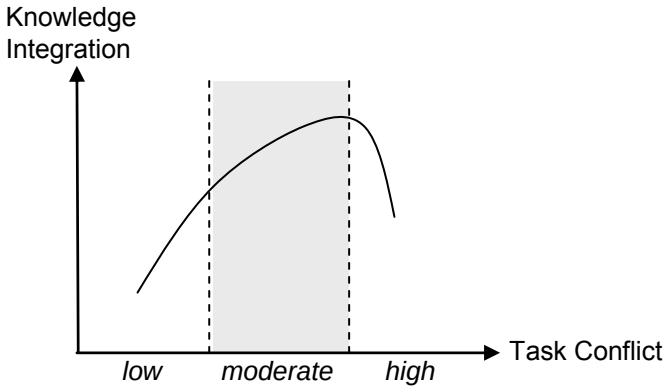

Figure 2: An Inverted-U-Relationship of Task Conflict and Knowledge Integration (Proposition)

*Task conflic*t (that increases group's effectiveness) and *relationship conflict* (that reduces it) are not independent, but *strongly correlated with each other.* Rather, more task conflict leads to more relationship conflict (De Dreu & Van Vianen, 2001; De Dreu & Weingart, 2003; Simons & Peterson, 2000). Simons and Peterson (2000) report eleven studies who could show that content conflict is highly correlated with relationship conflict (range r = -.17 to .88, mean r = .47). As argue Eisenhardt and her colleagues (2000) and much earlier already Argyris and Schon (1978), a plausible explanation for this is that people often understand a critique, that is intended on a content level, as a personal attack. Simon and Peterson call this a misattribution of task conflict, in which the participants of a conversation engage in biased information processing and self-fulfilling prophecies. They induce intentions and hidden agendas and see them confirmed in their interpretations of the others' ambiguous behaviour (Simons & Peterson, 2000). Such a misattribution more easily takes place if conversation partners express their content conflict poorly and use harsh and homonym language. On the other hand, a misattribution of relationship conflict as task conflict is equally possible. People masquerade their inter-relational problems as task issues and continue to sabotage a person by bringing up hesi-

tations and critique on a content level (Simons & Peterson, 2000). It is for all these reasons that substantive issues can no longer be separated from those based on personalities.

This correlation between task and relationship conflict poses a dilemma in dealing with conflict. If we aim to have a moderate level of task conflict to create a deeper understanding and a better integration of knowledge, we risk, at the same time, that the task conflict is (mis)understood on a relational level (as a relationship conflict) and that the overall outcome in terms of team performance, decision commitment, or decision satisfaction is negative.

Thus, three conflict conditions have to be present in order to allow for knowledge integration: 1. a moderate level of task conflict; 2. a low level of relationship conflict; 3. a low correlation between task conflict and relationship conflict. We define the concomitant occurrence of these three conditions as a situation of *constructive conflict*. We stipulate that:

H4: constructive conflict positively reflects the process of knowledge integration.

Decision Commitment

In order to conceptualize the second phase of knowledge integration, that is the integration of the systemic group knowledge into decision making and action, we include the variable *decision commitment*. The more the participants of a conversation are successful in integrating their individual specialized knowledge into systemic group knowledge (i.e. occurrence of first level knowledge integration), the more they will feel committed to the decisions taken. Decision commitment leads, as is discussed in the literature (see for example: Dooley *et al.*, 2000; Janis & Mann, 1977; Priem *et al.*, 1995; West & Schwenk, 1996), to a more successful implementation of decision and as Habermas claimed knowledge can be considered to be mutual and shared not simply if the participants agree in their opinions, but if they reach an intersubjective acknowledgement of demands of validity, that is if they accept something as binding for their future behaviour (Habermas, 1984: 573-374). In this understanding, the requirement is rather high for what is considered to the result of knowledge integration. Yet, this view draws the link between knowledge and the commitment to action. In other words, it implies that if knowledge really is integrated we can expect a stronger commitment to the decision taken. On the other hand, if the decision is not based on a real integration of knowledge, but rather on a unilateral exertion of influence, then also the commitment for the decision taken should be smaller. We therefore include ‘decision commitment’ as a dependent variable of our model, while clearly maintaining the central interest for the construct of ‘knowledge integra-

tion'. Prior research could show that a stronger decision commitment leads to a more successful implementation of the decision in action (Dooley et al., 2000). We claim that:

H5: decision commitment positively reflects the second phase of the knowledge integration process (integration of group knowledge into decision making) for that the better the knowledge integration of individual knowledge into group knowledge in the first phase, the higher the integration in the second phase (i.e. the higher the decision commitment).

Having outlined a communicative model for knowledge integration in decision making, we will discuss, in the next section, how the use of a software-based, interactive visualization tool impacts on the process how people integrate their specialized knowledge in systemic group knowledge and decision making.

The Role of an Collaborative Visualization Tool within the Process of Knowledge Integration

Approaches to the Study of Technology Use in Organizations

The role of technology for the processes of organizing and social interaction has been studied through a variety of theoretical lenses and approaches. Theses range from deterministic views on technology (for an overview, see: Bimber, 1998), in which technology affects people and social systems in quite dramatic ways, to theories of social construction (Pinch & Bijker, 1992), in which technology is viewed, on the one hand, as an artefact and an outcome of social interactions and that, on the other hand, is only mediating, and not determining, social processes and structures. Along this second stream, structuration theory (Giddens, 1984) is among the most widely used theories to study the interactions between information systems (IS) and organizational structures and processes. Jones and Karsten (2003) stated that more than 250 papers in IS made reference to Gidden's work. The most prominent further developments (in terms of an applicability of Gidden's structuration theory in the IS context) are both the adaptive structuration theory (DeSanctis & Poole, 1994) and the structurational model of technology (Orlikowski, 1992; Orlikowski & Robey, 1991).

The structuration theory is an attempt to see *social structure* (which mostly is the focus of positivist and functionalist sociologic theories, but also of structuralism) and *individual agency* (which has been stressed by interpretivist theories such as phenomenology or ethnomethodology) as a mutually interacting duality (Giddens, 1984: 1). Giddens defines social

structure as “rules and resources recursively implicated in social reproduction” (Giddens, 1984: xxxi) that is a set of *rules* and *resources* that are manifest in ongoing social practice. As such, social structure implicates a normative element in the sense that it constrains and enables certain types of behaviour. At the same time, it entails also codes of signification for how we create meaning of the environment around us. Social structure exists only in recurring action and at the same time mediates the latter (duality of structure) (Giddens, 1984: 19). As a consequence, in Gidden’s view, objects, such as technological artefacts, do not carry social structure (Orlikowski, 2000). Yet, in one of its most widely used applied versions, in adaptive structuration theory (DeSanctis & Poole, 1994), technology is said to reflect existing social structures, which are present among the interactions of its designers. Developers of a technology share dominant interpretations and interests and ‘inscribe’ (DeSanctis & Poole, 1994; Latour, 1992; Orlikowski, 1992) certain interpretative schemes and (social) norms into their artefacts. This idea differs from the one proposed by Giddens. In his view, recurring social practice is the central motor of structuring, and even if technology is characterized by a set of properties, the way how these properties will be actually used is not predetermined by the technological artefact alone (Giddens, 1984). Users, depending on their needs, their knowledge and skills, but also depending on situational factors (e.g. accessibility of recipient, diffusion and acceptability of technology within community or organization) (Markus, 1994), develop their own way of how to make use of the technology. The social structures that emerge from the interaction with the technology therefore are related to the properties of the *technological artefact* (e.g. feature of a groupware software that allows the anonymous posting of comments), to the type of *task* with which is dealt (e.g. level of complexity), to the knowledge, assumptions and expectations of its *users* (e.g. familiarity with task or technology), and to the existing social structures (e.g. habits, norms, values, and power relations) of the *community and organization* of which the users are part (DeSanctis & Poole, 1994; Orlikowski, 2000).

For the purpose of this study, ideas of structuration are very insightful. Social structure enables and constrains conversational practices, and is continuously consolidated, but also changed through these same recurring practices. We have argued earlier that we make sense, create, share, and integrate knowledge in social interactions and particularly in face-to-face conversations. Put in Gidden’s terms, that means that we use the social structures that emerge in our recurring conversations as the interpretive schemes for our sense-making and for the way experts and decision makers integrate knowledge. The question that emerges regarding the relation between knowledge integration, conversations, and conversational tools is therefore *whether the ways that technology is enacted alters in any form the conversational prac-*

tices and whether these new conversational forms represent a more suited frame for the integration of knowledge. More precisely, the question is *whether the appropriation of the tool leads to conversational practices that better cope with the communicational challenges of turn-taking, big picture, common ground, and conflict,* whose successful handling are defining elements of the knowledge integration processes as we discussed earlier on.

An appropriation or enactment of a technology is not immediate, but involves a more or less time-intensive process of various iterating activities. Orlikowski et al. (1995) discussed such mediating activities, among which activities of *establishment* (institute technology physically and socially, define physical parameters of technology, convince people of its necessity, set up roles and guidelines for use), of *reinforcement* (maintain operational fidelity, help users to adopt), of *adjustment* (alter technical features and usage rules), and activities of *episodic change* (redesign technical features, modify institutional properties of organization). Important aspects within theses activities are the characteristics of the individuals who promote or use the technology (i.e. their centrality within the social network of the organization, their formal power), or the organizational situation into which the technology is introduced (i.e. part of a larger change initiative). Technology is thus not enacted at once and its moderating influence on the process of knowledge integration should be studied within an – at least – medium timeframe.

On the other hand, the *first impression and experiences* are decisive for whether people feel committed to continue working with the technology. When establishing the new technology physically and socially within the institution, its initiators and promoters have to engage in an organizational discourse about the technology; they have to continuously argue for the technology's role, persuade managers, discuss the idea, and solicit feedback (Orlikowski et al., 1995: 440; Swanson, 2003). Yet, a very determining argument in this organizational discourse is the *first contact* with the technology itself. If users' first impression is that the technology is complicated in its employment or does not bring an immediate and apparent benefit, it is most likely that the managers and potential users will not consider it any further unless they have a strong incentive or pressure to do so. This study only examines such a first use of a specific technology. It will provide a first empirical test of the immediate benefits of the use of an interactive visualization tool on the process of knowledge integration and gives an answer to the question whether using the tool in a first moment leads to changes in the conversation process, which are favourable for knowledge integration. Certainly, conversation partners will not immediately alter their implicit guiding rules for leading conversations and their interaction

structures will remain the same. Yet, a first contact with the technology makes them try out alternative conversational patterns and processes. The features and the spirit (DeSanctis & Poole, 1994; DeSanctis *et al.*, 1994) of the tool, as understood by the participants of a conversation, confronts them with different, more or less explicit rules how to handle group participation, conflict, the establishment and sustaining of the big picture and of the common ground in our conversations. In a rather playful manner, they can try out these proposed rules and resources and see whether they bring them any benefits. This benefit perceived of the technology in its first uses will be determinant for whether people continue to be motivated to further use and enact the tool.

The Use of Visualizations in Conversations

The idea to use *interactive visual support* in conversations to enhance understanding is very old. Stafford refers to the frequent use of visuals to accompany conversations on knowledge-intensive issues already in the eighteenth century: Instruments, images, toys, preparations, cosmorama, or frontispieces were used as "interactive and flowing systems for understanding which were based on an ephemeral act of creation and which we now know as conversations" (Stafford, 1994: 25). Stafford outlines that the modus operandi of a conversation is very close to the one of the interaction with a visual.

In today's conversations and meetings, we still use many of the instruments that were popular then, but we have developed new ones, some of which are bound to the recent improvements in information and communication technologies (ICT) and have led to additional possibilities in the use of visualization. Next to handouts, sketches on flipcharts or blackboards, printed images and figures or physical models, participants of a conversation use media as overhead projectors, computer beamers, interactive softboards, touch screens, (streamed) audio-video, etc. These new media allow for new possibilities in supporting meetings that go beyond visualization (i.e. immediate access to the necessary information through databases, the real-time testing of scenarios, the inclusion of conversation partners that are physically distant, participative decision making through voting structures). Visuals have become more dynamic and can be easily constructed in a collaborative and interactive manner. In addition, the combinations and back and forth switches from electronic to physical presentations mark subtle changes in fluidity (in the electronic format, issues can be easily changed, if printed out, they become more official, decided and binding). Finally, an instant visual documentation of meetings and conversations and a company-wide distribution of these vis-

ual-minutes has become possible (Mengis & Eppler, 2005b). *Figure 3* shows an example of an interactive visual tool, which is designed to support the knowledge creation (idea generation) and structuring in conversations.

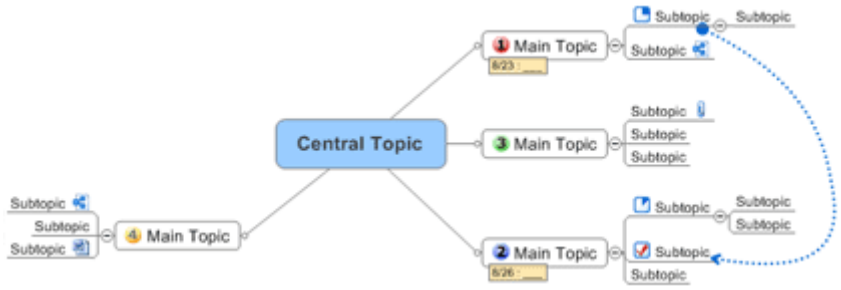

Figure 3: ***Example of an Collaborative Visual Tool - Mindjet MindManager Pro 6 (www.mindjet.com)***

In spite of these new possibilities in enhancing conversations, the scientific discussion on the use of collaborative visuals for face-to-face conversations has remained rather limited. Researchers have mainly focused on computer mediated communication (CMC) and on conversations of geographically dispersed interaction partners (i.e. online conversations through chat applications). In this context, a main interest has been to find ways to make up for the lacking visual and social cues by leaving a persistent trace of the conversation and allowing for correctibility (Bregman & Haythornthwaite, 2001). Also in the face-to-face context, there are a few examples of gaining persistence in conversations by using visualization (Lyons *et al.*, 2004; Waibel *et al.*, 1998). Yet, the major reasons for visualizing face-to-face conversations are to display the "thinking" of the conversation partners, respectively to depict casual arguments and relationships of concepts (Conklin, 2006; Conklin & Begeman, 1988). Visualization can also be used to make peripherical social information tangible (DiMicco *et al.*, 2004), or to visualize the human voice (Levin & Lieberman, 2004).

In the following, we will discuss the role of collaborative visualization for the presented model for knowledge integration. In particular, we will refer to a type of interactivity and visualization as it is provided by the software suite 'let's focus' (for a more detailed description of this tool, see: methods/tool). We do so since we have worked with let's focus for the empirical evaluation of the model for knowledge integration and for assessing the moderation effect of the tool.

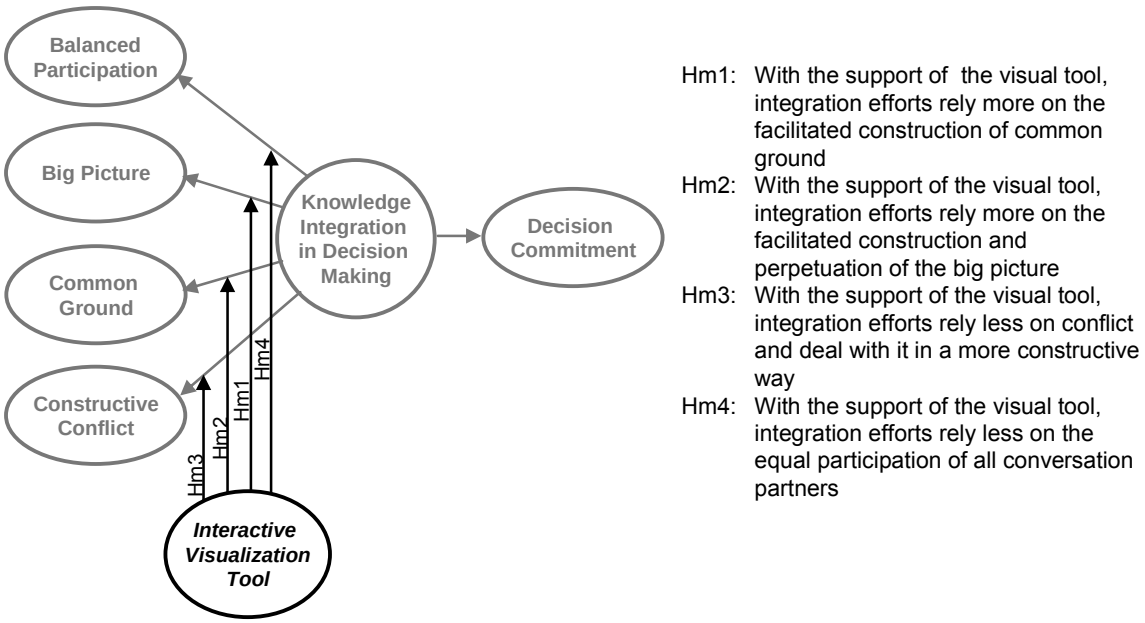

Figure 4: Moderation Effect of the Use of Interactive Visual Tools (Hm1, Hm2, Hm3, Hm4)

We claim that the use of the visual tool has a positive moderation effect on the model for knowledge integration (see: *Figure 4*) and propose four moderation hypotheses. In particular, we propose that experts and decision makers, who use an interactive visual tool (like let's focus) for their conversations, rely more on the creation of the big picture (Hm1) and the common ground (Hm2) in their knowledge integration efforts and less so on conflict (and if it arises, they manage to deal with it in a more constructive way) (Hm3) and equal participation (Hm4). Instead, in the non-supported condition, experts and decision makers, when aiming to integrate their specialized knowledge by unsupported conversations, the challenges of creating a big picture and a common ground are only difficultly to be met so that conversation partners rely more on equal participation and conflict in their attempts to integrate knowledge. Yet, they do not manage to handle with conflict in a constructive way, which is why, overall, their integration capacity is smaller in the non-supported condition than for conversation partners working with an interactive visual tool. We therewith claim that the use of an interactive visual tool has a positive moderation effect on a relational level of the presented model for knowledge integration (and not on a level of the means).

In the following, we will outline all four moderation hypotheses.

Moderation Hypothesis One (Hm1): With the support of the visual tool, integration efforts rely more on the facilitated construction of common ground

Several studies have argued for the importance of shared visual spaces in creating common ground among interaction partners who need to integrate knowledge (see for example: Bechky, 2003; see for example: Carlile, 2002). According to Carlile, a visual (which in his view is a specific instance of a boundary object) can become a shared resource and a common reference point and can help to establish a shared language among people and represent their knowledge so that they can better understand differences and communalities of their understandings (Carlile, 2002). Other studies focus more explicitly on conversations and discuss the role of visuals in establishing a common ground (Kraut *et al.*, 2003; Olson & Olson, 2000). They found - by confronting co-located interaction situations with geographically dispersed settings – that communicative grounding is facilitated significantly in the dislocated situation if interlocutors can use visual support (e.g. through video communication systems) (Kraut *et al.*, 2003; Olson & Olson, 2000). We believe that also in the co-located situation, the use of interactive visuals facilitates the construction of common ground since they provide additional physical co-presence. Conversation partners will therefore rely more on this facilitated construction of common ground in their attempts to integrate knowledge.

Interaction partners can refer to these shared visual objects by using deictic speech (words like ‘this’ ‘there’ ‘I’ ‘then’ that have no fixed meaning, but that point to a person, place, or time and are conferred with meaning by the communicative context, Jesperson called them ‘shifters’ (Jespersen, 1922)). Since the visuals are dynamic and can be changed throughout the conversation process, the refinement and correction processes (that are most important for grounding activities) can be achieved not only through verbal communication, but are also supported through the interactively developed visual. Reviewing the current state of the visual, a conversation partner might see that an identified problem (e.g. technological change), which was categorized as an external problem, should instead be viewed as an internal problem (e.g. the real problem is that they do not have processes in place that are flexible enough to swiftly adapt to technological change). The interactive visual permits interlocutors ‘reviewability’ (i.e. they can re-examine each other’s messages), which is an important aspect for building common ground (Clark & Brennan, 1991). In addition to reviewability, these authors listed a set of characteristics of communication formats (e.g. co-presence, visibility, audibility, contemporality), which allow for the construction of common ground (Clark & Brennan, 1991; Kraut et al., 2003). These are:

- Co-presence: interlocutors share the same physical environment
- Visibility: communicators are visible to each other
- Audibility: interlocutors can communicate through speech
- Contemporality: message is received the moment it is sent
- Simultaneity: all communicators can send and receive at the same time
- Sequentiality: turns cannot get out of sequence
- Reviewability: communicators are able to re-examine each other's messages
- Revisability: one can modify messages before they are sent

Clark and Brennan argued that while face-to-face conversations are characterized by most of the above listed aspects (and therefore represent a very apt communicational form for building common ground), they do not allow for reviewability and revisability (Clark & Brennan, 1991). Yet, when working with interactive templates that visually summarize the arguments and topics that are brought in during the conversation, interaction partners have the possibility to review others' arguments and refine their understanding even at a later stage.

Next to enhancing the referencing to physical objects and to providing reviewability, interactive visuals facilitate grounding also because they provide communicators with an *additional, often metaphoric language* (Kraut *et al.*, 2003). Visual language can help conversation partners to articulate aspects that are implicit and hard to define (Meyer, 1991). This is especially the case for visuals that rely on metaphors. Nonaka and his colleagues argue that the use of metaphors is key in the externalization phase (i.e. when people engage in the difficult process of giving an explicit form to tacit knowledge) since metaphors permit to understand one thing by imagining another (Nonaka & Konno, 1998; Nonaka & Takeuchi, 1995; Nonaka *et al.*, 2000). Having at disposition a visual metaphor (i.e. a bridge, a labyrinth, a scale, or a ruler), interlocutors refer to an already existing common ground between them. The attachment of abstract, unknown, and complex concepts and relationships (i.e. the topic (Lakoff & Johnson, 1980)) on the visual vehicle of the metaphor represents a clever way how to use the existing common ground in order to extend it. In this way, conversation partners can communicate something domain specific, abstract, or something that is hard to grasp with words by using the specific and well known concept of the metaphoric vehicle (Inns, 2002). They can use the visual language and the conceptual domain of the metaphor, which are common ground to all participants. Participants of a conversation can, for example, place an identified problem at the very bottom of an iceberg or put two solutions close to each other. In these ex-

amples, the interlocutors can express the difficulty to access a particular problem or the relatedness of two types of solutions through the visual positioning of the concepts on the visual metaphor. The visual language helps them to express aspects, which are difficult to put in words.

Finally, the visual language provides not only additional means for the expression of difficult issues; it also facilitates the understanding process. Images are said to afford a more direct access to meaning (Meyer, 1991). If information that is unfamiliar to people is visualized on a well-known object (like, for example, on a funnel, a boat, or a ladder, and, to less extent, also on a diagram like the Ansoff-matrix or a Strategy Map), people can quite intuitively explore the meaning of the unfamiliar and of the aspects that are not yet common ground (see also: Inns, 2002).

The use of visuals in conversations gives interlocutors the possibility to use the existing common ground among them and to extend it to new conceptual domains. In doing so, visuals facilitate both the expression of issues that are abstract, complex, and hard to express in words as also their understanding. Because the use of visual tools makes it easier for experts and decision makers to construct a common ground among them, they will give more weight to it when integrating their knowledge than those interacting without a visual support.

Moderation Hypothesis Two (Hm2): With the support of the visual tool, integration efforts rely more on the facilitated construction and perpetuation of the big picture

Interactive visuals (as the ones provided by the software suite let's focus) allow conversation partners to visually document the synthesis of important arguments of their conversations and to structure them through the categories provided by the image. At the same time, the participants of a conversation also have the possibility to link, to this synthetic overview, more detailed information or reasons-why of a certain standpoint through the comment function of the tool. In this way, the visual tool helps to keeping the difficult balance between overview and detail, which is necessary for the creation and perpetuation of the big picture.

Visuals that are developed within the curse of the conversation help participants to keep in mind the current state of the conversation and serve as a *mnemonic device* of what has been discussed earlier on and what are the still missing themes in the conversation. Kraut, Fussel, and Siegel state that "visual information helps people maintain up-to-date mental models or situational awareness of the state of the task and other's activities. This awareness can help

them plan what to say or do next and to coordinate their utterances and actions with those of their partners" (Kraut et al., 2003: 15). Dynamic visuals serve as an artefact around which interlocutors can coordinate their contributions, both in terms of time and content. They are constantly reminded of the overall picture to which they contribute with their single statements. They can see what has been said before and what topics have not been touched so far in their discussion. In this way, the visual helps to maintain the big picture and the participants of a conversation can understand how the specific contributions relate to the overall topic.

Visuals are important for gaining and keeping the big picture also because they support *systemic thinking* and focusing on the *interconnections*, rather than the parts. Dimond and Beaumont (1974), Kosslyn (1978), and Maruyama (1986), as quoted by Meyer (1991), all argued that cognitive operations on images do not require their decomposition into single elements. In view of an image, people are inclined to think of the interrelationships between components rather than engaging in fragmentary thinking (Meyer, 1991). In a visual, the logic of presentation is not sequential. Various information elements are outlined in space and presented simultaneously. Meyer therefore argues that visuals serve for simultaneous processing of a variety of information and help to keep more information items in mind (Meyer, 1991: 222). Seeing various elements placed next to each other, conversation partners are invited to think whether there is a relationship between these and what the nature of such a relationship could be. If this visual is a framework that provides an all-embracing structure (which can be based on a metaphor or on a more abstract representation) along which interlocutors can position their contributions, the capability to interconnect and see the big picture is even more strongly enhanced (Vincent & Rosse, 2001). Finally, the work with interactive visual tools is a sort of a mapping activity, in which the important arguments are place on visual metaphors or on other visual support such as diagrams, tables or coordinate systems. Huff and Jenkins (Huff & Jenkins, 2002) mentioned that working with mapping techniques brings advantages such as, among others, connecting and organizing knowledge, or representing knowledge on different levels of abstraction. Using visual tools thus helps to interconnect, to think systemically, to better differentiate between the various levels of abstraction, and to create and maintain the big picture of a conversation. Being the creation of the big picture facilitated in the tool condition, experts and decision makers rely more on the big picture in integrating their knowledge.

Moderation Hypothesis Three (Hm3): With the support of the visual tool, integration efforts rely less on conflict and deal with it in a more constructive way

Conversation partners, who manage to have a necessary common ground among them and, second, are capable of seeing and maintaining the big picture of the issue of decision throughout the conversation process, need to refer less to conflict when integrating their knowledge. For example, if an interlocutor A holds another opinion or view than interlocutor B, but if both of them see the big picture of the issue, they have a better chance to see that their opposition might be resolved a higher level of abstraction. Similarly, if A knows interlocutor B well (that is they share a large common ground), but, on a specific issue, B disagrees with A, A might easily induce the reasons and motivations behind B's disagreement and develop an understanding for it. He/she can also more easily refer to these reasons and motivations and resolve the disagreement on this level. In this way, conversation partners who are interacting with the tool, mainly integrate their knowledge through common ground and big picture and task conflict is a less important element in the integration process.

We claim that, in the tool condition, conflict is not only less important for the integration of knowledge, interlocutors are also capable of dealing more constructively with arising conflict[2]. This means that conversation partners will report a moderate level of task conflict and do not mistake it for relationship conflict (low correlation). Visualizing standpoints and assertions increases the critical capability of the interlocutors. Cecez-Kecmanovic and Dalmaris (2000) found that when people can see the representation of a collective understanding or opinion, they can recognize the possible discrepancies with their own understanding. Such differences in opinion and inconsistencies in understanding are usually quite hard to detect, but become more apparent through the visual depiction. Participants can critically review the various elements and the relationships among them if they are visually outlined in front of them. Instead of an uncritical acknowledgement of facts, the visual leads to a certain amount of task conflict. Yet, the handling of this conflict is collaborative. The framing that the interactive visual provides is a one of integration: all contributions are potentially part of the same image. There is nothing beyond that image that could not be integrated and disagreements are only different perspectives of the same picture. In a subtle way, such an integrative image creates a more collaborative spirit among the conversation partners. Dichotomous (either-or) rea-

[2] Other important factors for dealing more constructively with conflict are the creation of within-team trust (Simons & Peterson, 2000) or introducing interactional rules as focusing in the debate on facts and multiplying alternatives and to enrich the level of debate (Eisenhardt et al., 2000). Furthermore, specific tools, like the self-assessment-tool proposed by Drucker, are said to help communicators to more openly listen to each other and to deal more constructively with conflict (Drucker, 1994).

soning (Tannen, 1999) and defensive arguing (Argyris, 1996) can be contained and with that the non-constructive handling of conflict. What in addition fosters a constructive handling of conflict is when conversation partners switch from one visual support to another. They can frame, for example, a negotiation situation as a pie for which the total value is defined upfront and of which each party tries to get the biggest piece. Alternatively, the same situation can be viewed as a bridge. In this frame, each party starts with a departing situation and can create additional value by building on the bridging, common interests. A change in the visual support permits conversation partners to alter their perspective on the issue and to re-frame their thinking (Inns, 2002). By doing so, they realize that their perspective is, to some degree, contingent, which leads them to approach differences of opinion in a more collaborative spirit.

Finally, by visualizing arguments and standpoints, these concepts receive a certain physical reality and are to some extent dissociated to the people who put them forward. The risk is thus lower to take a critique on an issue personally and to misunderstand a task conflict on a relational level. The correlation between relationship and task conflict is therefore lower. In sum, we claim that interlocutors, who interact with the support of a visual tool, refer less to conflict in order to integrate their knowledge and if they do so, they deal with it in a more constructive manner.

Moderation Hypothesis Four (Hm4): With the support of the visual tool, integration efforts rely less on the equal participation of all conversation partners

We have argued that an equal participation of all conversation partners is a basic reflection of knowledge integration. In both conditions (tool and non-tool), if a certain conversation partner does not participate at the conversation process, his/her knowledge cannot be integrated to a group knowledge. In this sense, equal participation remains important in both conditions. There are visualization tools for face-to-face conversation that visualize the peripherical social cues of the conversation like for example the amount of contributions of each interlocutor (DiMicco & Hollenbach, 2006; DiMicco et al., 2004; Sack, 2000). DiMicco and her colleagues (2004) found that in a co-located setting, providing visual cues on the amount of contributions of each conversation partner made much-talkers limit their amount of contributions and *equilibrated participation*. Since the visualization tool, which was employed for this experiment, does not visualize such social cues, we would not expect such an effect. Yet, we stipulate a similar effect like for the conflict construct. If the participants of a conversation do see the big picture of an issue, they more or less know which aspects they still need to discuss,

which information is missing, and where they have to develop novel approaches. In this sense, even if there were some more-talkers and less-talkers in the discussion, this is not forcibly seen as a threat to knowledge integration. The orientation on the conversational process is thus tightly bound to the content and scope of the discussion so that the strict distribution of the turns taken by the conversation partners is perceived to be less important for the integration of knowledge. Without the tool, conversation partners are more sensitive to interactional justice such as equal participation (Bies & Moag, 1986).

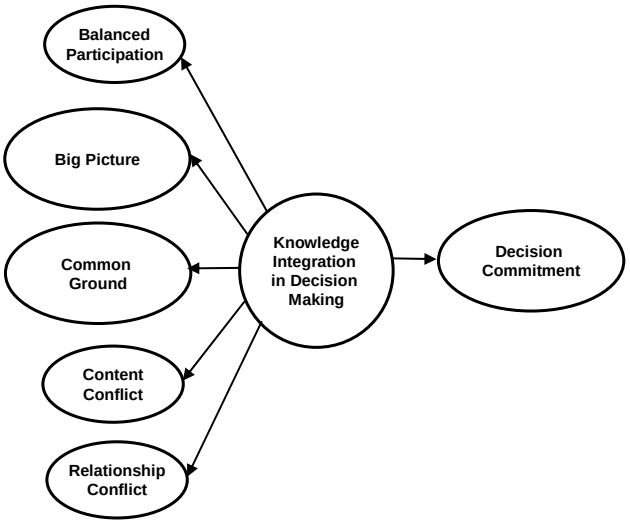

Figure 5: Moderation Effect of the Use of Interactive Visual Tools (Hm1, Hm2, Hm3, Hm4) Tool Condition: Importance of Variables Forming Knowledge Integration

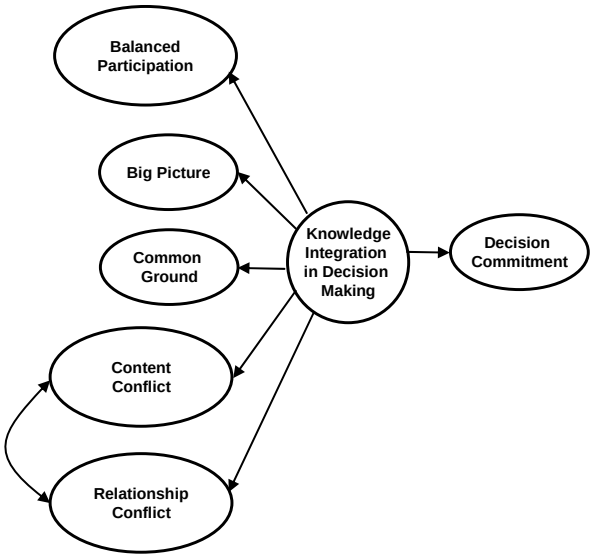

Figure 6: Non-Tool Condition: Importance of Variables Forming Knowledge Integration

To summarize, we stipulate that the visualization software has a positive moderating effect on a level of the relationships of our model and not on the level of the means. We claim that, in the tool condition, conversation partners integrate their knowledge mainly through the establishment of 'big picture' and a 'common ground' and that conflict and equal participation carry less weight (see: *Figure 5*). For the non-tool condition (see: *Figure 6*), we find the opposite situation. Because of a lack of common ground and big picture, interlocutors give more importance to conflict and equal participation. We further claim that, in the non-supported situation, interlocutors deal with conflict in a less constructive way for that relationship conflict and task conflict are more strongly correlated (moderate task conflict, moderate relationship conflict, and low correlation between them are forming constructive conflict, see: Operationalization of Research Variables and Measurement Model). Finally, there is a

stronger relation between knowledge integration and decision commitment in the tool condition (2nd level integration).

Methods

In the following, we will present a first empirical evaluation of the communicative model for knowledge integration and of the proposed moderation effect of the use of the interactive visual tool on the model. For this first evaluation, we conducted a class room experiment.

Design and Participants

The class room experiment involves a preference task (DeSanctis, 1987), in which subjects have to make a selection of alternatives for which there is no objective criterion of a correct answer. We use a between-subjects single factor group design, varying only the mode of communication (tool groups and non-tool groups). There are sixteen groups in total, eight groups per condition, and each group is formed by four subjects (a total of 64 respondents, 32 per condition). Each group consists of two "experts" and two "managers" and students are randomly assigned to the groups and their function within the group. Participants were undergraduate students in communication science that follow a strategy or knowledge management course.

Task

The preference task is based on a hidden profile scenario[3] (Stasser, 1992; Stasser & Stewart, 1992), in which there exists an information asymmetry between the single members

[3] The hidden profile setting, i.e. the information asymmetry and explicit role assignments (Stasser *et al.*, 2000) had the mere function to establish the role of the expert and the one of the decision maker. We did not pursue the classical objective of hidden profile studies, which is to analyze whether conversation partners have an inclination to share and consider information that is already shared among them (and to consider uniquely held information to a lesser extent). The mere difference in information and the explicit attribution of roles do not make a person to become an expert nor a manager. In fact, the language, mental models, past experiences, and the implicit knowledge of these 'experts' and 'decision makers' certainly do not differ in the way they do in a natural condition. Such a procedure though has been used in other experimental settings (Stasser et al., 2000) and we could suppose that if we can observe the said communicational challenges of knowledge integration already in this attenuated situation, they would be more blatant in a "real world" context.

of the group. In order to be able to make satisfying choices and to have enough information on the presented alternatives, conversation partners have to pool the unshared items.

Students receive a case study[4] on a small-medium enterprise (SME) and its knowledge management projects, some of which it intended to implement. On the basis of the case study, students have to decide which three of the five project proposal they would choose for actual implementation. Half of the students receive a version of the case that provides more information on the knowledge management projects (expert version) whereas the other half obtains more strategic, corporate information (decision maker version) (see: Appendix 1 and Appendix 2 for the two case versions). In total, the cases contain 12 information cues on corporate and strategy issues (of which only 3 are exposed in the expert version) and 52 cues on the knowledge management projects (of which only 11 are included in the manager version) (see: Appendix 3 for a comparative listing of the information cues for both case versions). Each group is formed of two experts (students who have read the expert version of the case), and two decision makers (who have read the management version). During the one hour experiment, students are asked to identify with the roles attributed to them through the case study and to imitate a one hour meeting.

In this meeting, two experts present five knowledge management measures and the CEO with another manager decide, which three of the five measures to actually implement. In the first half hour, in order to better understand the context, into which the knowledge management measures shall be implemented, the groups are asked to discuss the corporate objectives and problems of the company. They have to elaborate four criteria by which they will evaluate and choose the knowledge management measures. In the second part of the meeting, the students have to present, discuss, and evaluate the five proposed knowledge management measures. Finally, the two managers have to decide (by consultation of the experts), which three of the five measures to further pursue and implement. Figure *7* and Figure *8* outline exemplary solutions for the first and second part of the task, yet there is no one best solution for the given task. We used the software tools, with which half of the groups worked, as a visual support for the presentation of these solutions.

The task we have developed for the experiment had to satisfy the following criteria. First, the task needs to well imitate a real world problem and represent a good instance of a domain expert-decision maker interaction. It needs to be a problem, in which, decision makers

[4] For the original case study, see: (Eppler, 2002).

typically draw in experts for consultation. In such a situation, neither the experts nor the decision makers alone could have taken an informed decision. Decision makers call in experts only if they have to take a decision in a rather complex and uncertain environment where there is no one best solution. The task therefore needs to show a considerable level of complexity. In addition, we wanted to imitate the time pressure aspect, which is a major challenge in the expert-decision maker interaction. Finally, we were looking for a task, in which subjects already have some prior knowledge so that they can potentially bring into the discussion somewhat more implicit knowledge and not only report the explicit items from the case study. Since the respondents would be students that follow either a knowledge management or a strategy course, the task had to do with knowledge management, project management, and with strategy implementation.

Tool

The software tool we were using for the experiments is called *let's focus Positioner* and is part of the software package *let's focus*. The objective of let's focus is to support knowledge processes of individuals or groups by using interactive visualization methods. In particular, all applications of *let's focus* are thought to support face-to-face conversations as also computer mediated interactions.

The software has been developed conceptually by the authors and by the Reflact Inc., a German company developing and using new media for organizational development, which technically and graphically developed the tool. The software is based on Flash und Java technologies and uses XML standards for data formats and format conversions. It has been used in various organizations, including reinsurance groups, logistics providers, banks, and universities. Conceptually, let's focus is based on approaches of knowledge visualization, metaphor theory, Gestalt theory, and also on morphological research (let's-focus, 2006).

let's focus can be used as a support in various settings. It is said to support the facilitation of workshops, virtual meetings, interactive presentations, training seminars, and can also be used in more individualistic problem-solving situations (let's-focus, 2006). As a communication device, the producers claim that the tool helps to overcome communication fallacies as "circular discussions, suboptimal use of time, insufficient fact-checking and hazardous and rashly conclusions, misunderstandings, and unfruitful conflict" (Reflact & Eppler, 2005). Yet, the aim of let's focus is not only to serve as a communication device, but also to provide frames and conceptual structures for approaching specific task types like evaluative tasks (e.g.

client- or competitor assessments, option evaluations) or more general analytic tasks (e.g. problem analysis, stakeholder analysis) and also planning tasks (e.g. project or campaign planning meetings). In order to support these various tasks, the software package includes four tools: the *let's focus Timeliner*, the *let's focus Ruler*, the *let's focus Tracker*, and the *let's focus Positioner* (for an overview on the various tools, see: *Appendix 4*).

The *let's focus Positioner* is the tool we have used for the experiment. The Positioner is intended to support groups to share information, analyze complex issues and to structure the integration of various types of information. The tool provides a large library of interactive and in part animated templates of diagrams and metaphors along which the user can position objects such as textboxes and symbols and visually underlie the relation between them. The tool includes functionalities of clustering, annotation, replay, levelling, and overlaying, all of them using simple drag and drop logics and which allow users to visualize their thinking and communication processes.

A description of the specific features of *let's focus Positioner* can be found in *Appendix 5*. We will limit ourselves to present only one distinguishing feature of the application, which is that its user (e.g. the moderator of a meeting) can choose between a variety of *backgrounds and templates*. These represent diagrams (i.e. Fishbone, Balanced Scorecard, Five Forces, Value Chain, or Ansoff Matrix) or visual metaphors (i.e. a radar, an iceberg, a bridge, geographical maps, a ladder, a pyramid, a wheel, or a funnel). The templates combine such a background visual with some default text-fields and objects and provide more guided structure in approaching specific tasks such as, for example, a stakeholder analysis. The idea is that the individual or group selects a visual guideline or cognitive and communicative frame with which to approach and structure an issue or conversation. Since these frames are visible to all conversation partners, they are likely to provide a common ground and language to all the participants of a conversation and facilitate understanding.

For the experiment, we prepared two templates, one for the corporate discussion and elaboration of evaluation criteria, the second for the evaluation of the proposed measures.

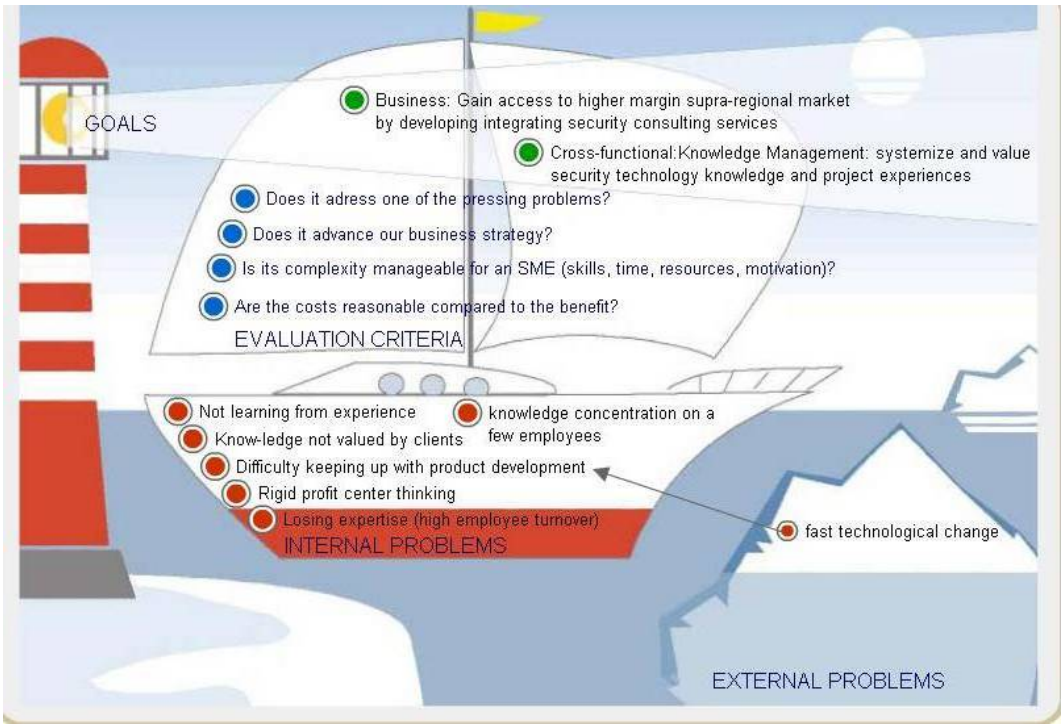

Figure 7: Template (Based on a Compound Metaphor) and Exemplary Solution for the First Part of the Task: Understanding Corporate Objectives, Problems and Defining Evaluation Criteria

The first template (see: Figure *7*) is based on the visual metaphor including a sailing boat that is floating in the sea. It is guided by the light of a lighthouse and is threatened by underwater icebergs. The template invites interlocutors to place the organization's internal problems in the bow of the ship, the external threats on the iceberg, the objectives of the company on the lighthouse's light beam and, finally, the criteria for the evaluation of the knowledge management measures in the middle of the picture, on the sails.

The second template (see: Figure *8*) is more analytic and includes a table that allows for evaluating how good each knowledge management measure corresponds to the previously developed evaluation criteria. On the left row of the table of Figure *8*, evaluation criteria are transferred and on the upper cells.

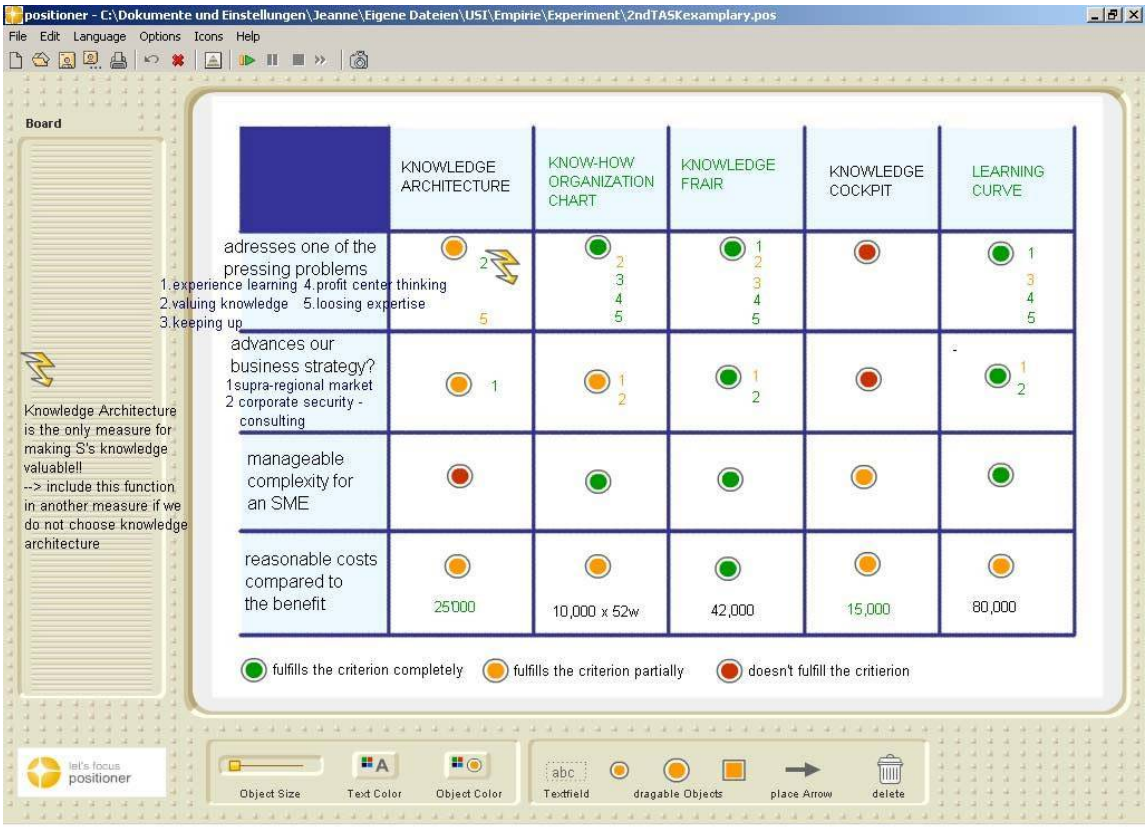

***Figure** 8: Template and Exemplary Solution for the Second Part of the Task: Evaluating Proposals of Five Knowledge Management Projects*

Setting

All groups are sitting in a small lecturing room on a square table, the two 'experts' on one side, the 'managers' on the other, but all facing each other. The groups of the tool-supported condition have a notebook and a mouse placed on the table, which can be handled by one of the group members (see: *Figure 9*). To facilitate the visibility of graphic template, the computer screen is projected by a beamer. All groups are audio and videotaped during the one hour interaction.

Figure 9: Group Conversing with the Use of let's focus Positioner

Pretest

The initial questionnaire was reviewed by an expert on experimental design and was tested on five people before we conducted the pre-test experiment. First changes were taken into consideration.

In order to test the design, procedure, and questionnaire of the experiment, we conducted a pre-test with an executive master class of 32 students (8 groups). At this stage, we handed out the case study just 30 minutes prior to the experiment and gave only a very brief introduction to the tool. Also, the task was more complex and involved an hour discussion that was divided in three parts: 1. sharing corporate information and elaboration of evaluation criteria for the knowledge management measures (with the support of the let's focus Positioner); 2. sharing of project information and deciding three knowledge management measures to implement (with the support of the let's focus Positioner); 3. planning action steps for implementing the decision (with the support of the let's focus Timeliner). The students had 20 minutes for each task.

At the end of the experiment, we held a plenary discussion with all the participants and asked feedback on the task, on the use of the tool, and on the questionnaire. We analyzed the questionnaires and changed the few questions to which several people hadn't responded. We also analyzed the outcome of the questionnaires and found moderate confirmatory results on most variables.

From the insights gained through the observation during the task, the results of the questionnaires and the plenary feedback session, we slightly changed procedure, task and questionnaire of the experiment. First, students should be more strongly familiarized with the tool. We decided that all students (the ones who will use the tool and the ones who will not) would receive a brief conceptual and practical introduction to the tool and they would use the tool in a task in the days and lesson previous to the experiment. Second, we would make them read the case study not right before the experiment, but would give it as homework for the day of the experiment. In the pre-test, the overall time schedule was very tight and the overall time request quite long (together with the reading of the case and the plenary discussion). We realized that students were quite tired and less motivated at the end. For the same reason of time and motivation, we shortened the task of the experiment and skipped the third part. That also brought the advantage that students had to use only one tool of the let's focus suite (Positioner) and were able to focus more on the task and less on the learning of the tool. Finally, we made some changes in the questionnaire, we added some questions for the big picture construct, the common ground construct, and included some control questions on the level of familiarity with the task.

Procedure

After pre-testing questionnaire and procedure, we conducted the experiment in the following way. By email or in a lesson prior to the training for the experiment, students were asked to confirm their participation at the experiment. Two lessons before the day of the experiment, all students (independently of whether they were part of tool or non-tool group) received a brief introduction to the tool (ideas behind it, possible uses, how to use it). Students also had to do an exercise for homework with the tool that they then had to present in class. In this way, we were able to assure that students have some familiarity in the use of the tool. A day or as a maximum a week before the experiment, the students received the 5- respectively 8-page case study, which they had to read for the day of the experiment. They were urged not to share information among them prior to the experiment.

The day of the experiment, students were split into groups and received 10 minutes to again scan through the case study. The single groups were reminded that they were now part of a living case study and found themselves in a one-hour meeting in which they had to share information and make several decisions. For the tool groups, the supervisor also showed which visual template to use for the first part of the meeting and which for the second part. The

groups working with the tool chose one participant of the conversation to handle the tool and visualize the contributions of all members along the discussion. After the one hour discussion, the groups were asked to collectively fill in a form in which they had to outline which projects they had chosen and argue why they had chosen them. In addition, they were asked to fill in a questionnaire, which took 15 minutes for compilation.

Operationalization of Research Variables and Measurement Model

All research variables are measured using multi-item scales (see Appendix 7 for original scales and *Table 1* for adjusted scales after assessment of psychometric properties).

We have developed own scales for the constructs of Common Ground, Big Picture, and Decision Commitment and relied on already developed scales for Equal Participation (Murthy & Kerr, 2003) (to which we added some additional items), Content and Relationship Conflict (Pearson, 2002).

Equal Participation

We have measured the equal participation construct with a 3-item scale including the following items: 1. There was an adequate participation from all members of the group; 2. There were one or two people who dominated the discussion, and 3. The other members of my group paid attention to the comments I made. We borrowed item 1. from Murthy and Kerr (2003) and added 2. and 3. We have introduced item 3 since equal participation is not only about making turns and actively contributing to the conversation. It is also about whether these contributions are actually considered and whether participation on behalf of the listeners (not only the speakers) is equal. If all participants engage in equal turn taking, but nobody listens nor takes into account what participant A says, the turn taking might be equal, but not so the participation.

Big Picture

To our knowledge, the big picture challenge has not been object of empirical studies that applied quantitative measurement methods. For this reason, we have developed an 6-item scale based on the insights we gained from the explorative case studies from the conceptualization in the existing literature (Gasper & Clore, 2002; Harkins, 1999; Rhodes, 1991; Ringach, 2003). The scale reflects a communicative, process oriented view on the big picture challenge and consists of the following items: 1. The conversation process was very clear; 2. We never

lost time on discussing irrelevant issues; 3. We never lost time on too detailed discussions; 4. I always knew how a specific contribution related to the more general topic of the discussion; 5. At every point in time I knew why the group was discussing a specific issue; and 6. I knew at every point in time where we were in the discussion. As a response scale, we have used the 5-point Likert scale ranging from (0=”strongly agree”) to 4 (=”strongly disagree”). The scale was pilot-tested using a sample of 32 respondents and fine-tuned in the following.

Common Ground

As is the case for the big picture construct, we are not aware of an empirical study in which common ground was measured quantitatively. Again, on the basis of the insights drawn from our explorative case studies and of the existing literature (Clark & Brennan, 1991; Clark & Marshall, 1981; Krauss & Fussell, 1991), we have developed an own measurement scale. We wanted it to reflect three elements that we think are important for the common ground construct. First, the differences or communalities in *language* use were often reported in the case studies as a proxy for a whole set of differences such as knowledge background, training, everyday context, personal perspectives and values. Second, the concept should enclose whether the participants managed to enlarge the intersection of their specialized knowledge sets and integrate it in order to create a *shared understanding*. Finally, the scale should reflect the interlocutors’ capacity to put themselves in the perspective of the others (Krauss & Fussell, 1998) and adapt their messages to it. We formulated the resulting 3-item scale as follows: 1. During the conversation, the group developed and shared a common language to deal with the task; 2. During the conversation, the group created a shared and deep understanding of the topic; and 3. I could now better adjust my communication style to the other members of the group. As a response scale, we have worked with the 5-point Likert scale ranging from 0 (=”strongly agree”) to 4 (=”strongly disagree”).

Constructive Conflict

We have bound constructive conflict to three conditions: 1. moderate task conflict (inverted u-curve relationship), 2. low relationship conflict, 3. low correlation between task and relationship conflict (see: Constructive Conflict). In order to avoid a third order latent variable, we do not introduce constructive conflict as a second order latent variable for the statistical analysis, but work directly with task conflict, relationship conflict, and the correlation between this two constructs.

For the measurement of the two interrelated conflict constructs, we relied on Pearson, Ensley, and Amason's (Pearson, 2002) 6-item scale. They developed their scale on the basis of Jen's famous Intragroup Conflict Scale, who developed a measurement for the two discussed dimensions of conflict (Jehn, 1995). Pearson et al.'s scale for *relationship conflict* consists of three items, which we took over: For one relationship conflict item "How much tension was there in the group during decision?" we replaced "during decisions" with "during the exercise" as our focus was on the whole one hour group interaction and not merely on the moments people took decisions. For the task conflict item "How many disagreements regarding different ideas were there?" we added "during the one hour discussion". For both task conflict and relationship conflict, the responses were recorded on a 5-point Likert-type scale ranging from 0 (="none") to 4 (="a great deal"). In order to model the curvilinear relationship (inverted u-shape) for task conflict, we introduced a quadratic component to the linear function (x^2) (Backhaus *et al.*, 2003).

Decision Commitment

We measured the level of 'decision commitment' with a 3-item scale we have developed ourselves: 1. I feel confident that our group made the right decisions; 2. The group was better at making the decision than I could have done by myself; 3. The decisions were unanimous 4. There was a lot of agreement in the group. As a response scale, we have used the 5-point Likert scale ranging from (0="strongly agree") to 4 (="strongly disagree").

Mode of Analysis

The model we have presented for knowledge integration is an indirect reflective, second order model with multiple mediating constructs. In view of the type of model, but considering our limited sample size, we will do a combination of structural equation modelling (SEM) technique and traditional confirmatory factor analysis. SEM allows for the simultaneous analysis of all relationships in a model (and not merely the linkage between two constructs at a time), and, more importantly for this study, for the analysis of models that include second order latent variables. Yet, an important drawback of SEM is the need for a large minimal sample size. While traditional regression analysis requires a minimum of only 30 cases to obtain robust results, in SEM, accepted minimal samples size range from 50 (if we operate with loading factors of more than 0.75) (Hair *et al.*, 1998) to the more accepted 100 to 150 cases (Gefen, 2000). In view of models with second order latent variables, authors even mention 200 as an accepted minimal (MacCallum *et al.*, 1996). Other scholars define minimal sample size

in terms ratio of observations to parameters to be estimated (Jackson, 2003) and fix the ratio at 10:1 or even 20:1 (Kline, 1998). Barclay and his colleagues state, for example, that the sample should have at least ten times more data-points than the number of items in the most complex construct in the model (Barclay *et al.*, 1995).

In view of our small sample size of 64 respondents (32 for each condition), we can obtain relatively robust results only when performing traditional regression analysis. Yet, since this type of analysis is not possible for the model we have proposed, we have opted for a combined approach (Hair et al., 1998; MacCallum et al., 1996; MacCallum *et al.*, 1999). We first conducted a confirmatory factor analysis (with the support of the software package SPSS) for the first order latent constructs, then introduced those constructs – in the form of indicators - in the AMOS program and treated them as observed variables. Even if approaching the analysis this way, the problem of minimal sample size is not fully resolved so that this analysis can only be seen as a first inconclusive analysis that helps us to refine the model and our hypotheses for further studies that allow for an analysis with more statistical power.

Structural equation modelling (SEM) was used to examine the construct of knowledge integration and its hypothesised dimensional indicators: equal participation, big picture, common ground, constructive conflict (low level of task conflict, lack of relationship conflict). In addition, it aims to understand the moderation effect of the use of content-specific, interactive visualization support on the model of knowledge integration.

Results

Descriptive Statistics

In this section, we will present the results of the descriptive and factorial analysis. Since our hypotheses are on a structural level, we will not discuss distributions, frequencies, or central tendency in detail. Instead, we limit ourselves to address briefly issues concerning the normality of distribution, the results of the confirmatory factor analysis, the mean and standard deviation of the latent variables and the discussion of the qualitative questions of the questionnaire.

In total, 64 people participated at the experiment, that is 32 respondents for both the tool and non tool condition and a total of 16 groups (each of which consists of four people). The unit of analysis was set at the individual level. 23 of the participants were men, 41 were

female. We have 4 missing data, but in view of our already small sample size, we decided not to proceed with a listwise, but with a casewise exclusion of the cases that showed missing values. The discussion of the normality of the distribution can be found in Appendix 6.

Table 1 shows the results of the confirmatory factor analysis that is the *psychonometric properties of the adjusted scales* assessed in terms of the item loadings, the eigenvalues, the percentages of explained variance, and the Cronbach alphas. For the factor loadings, we used a cut-off criteria of 0.60 and for the Cronbach alphas of 0.70 (Devellis, 1991). The original scales with their psychonometric properties can be seen in Appendix 7.

Factor	Item	Factor Loading	% of variance explained	Cronbach alpha	Mean (S.D.)
Equal Participation (EP)	1. There were not one or two people who dominated the discussion	.891	0.79	0.74	1.04 (0.85)
	2. There was an adequate participation from all members of the group.	.891			
Big Picture (BP)	1. The conversation process was very clear	.806	0.48	0.78	1.23 (0.57)
	2. We never lost time on discussing irrelevant issues	.724			
	3. We never lost time on too detailed discussions	.602			
	4. I always knew how a specific contribution related to the more general topic of the discussion.	.603			
	5. At every point in time I knew why the group was discussing a specific issue.	.774			
	6. I knew at every point in time where we where in the discussion	.632			
Common Ground (CG)	1. During the discussion the group created a shared and deep understanding of the topic.	.879	0.77	0.70	0.95 (0.56)
	2. During the conversation, the group developed and shared a common language to deal with the task	.879			
Task Conflict (TC)	1. How many disagreements regarding different ideas were there during the one hour discussion?	.838	0.65	0.73	2.60 (0.56)
	2. How many differences about the content of decisions did the group have to work through?	.749			
	3. How many differences of opinion were there within the group?	.837			
Relationship Conflict (RC)	1. How much anger was there among the members of the group?	.854	0.78	0.85	3.60 (0.65)
	2. How much tension was there in the group during the exercise?	.898			
	3. How much personal friction was there in the group during decisions?	.901			
Decision Commitment (DC)	1. I feel confident that our group made the right decisions	-	-	-	0.92 (0.63)

Table 1: Factor Loadings, Percentages of Variance Explained, Cronbach Alphas, Mean Values, and Standard Deviations of First Order Latent Variables

Notes regarding the mean values: All constructs are measured with five-point Likert scales with the anchors 0 = strongly agree, 2 = neither/nor, 4 = strongly disagree, except for Task Conflict and Relationship Conflict that have five-point scales ranging from 0 = none, 4 = a very great deal

We were able to maintain the original scales for most of the constructs, but had to adapt them for 'equal participation' and 'decision commitment'. With regard to 'equal participation', we had to drop the item that checked for the equality in participation not with regard to the speakers and their turns made, but with regard to the listeners and their active consideration of what is said (The other members of my group paid attention to the comments I made.).

Concerning the 'decision commitment' construct showed Cronbach alphas below 0.70 for the original 4-item scale, as well as for the various 3- and 2-item scale versions. Even though we have significant correlations for example between questions 1, 2, 4 (I feel confident that our group made the right decisions; The group was better at making the decision than I could have done by myself; There was a lot of agreement in the group) and factor loading of above 0.70, we have insufficient Cronbach alphas. Apparently, the items, even if correlated do not measure the same characteristic of the decision commitment construct. Question 2 points more versus group performance, and agreeing is not the same as committing. Von Krogh et al. (2000: 134) for example made the argument that agreeing does not equal understanding. Rather, agreeing is a commodity, which does not require understanding. Similarly, we could say that an agreement without a full understanding does not necessary lead to more commitment. Out of this factorial analysis, we had to decide to work only with one item and have chosen the most straightforward one: I feel confident that our group made the right decisions. Overall, the choice to work with a pre-established scale for decision commitment, as for example the one proposed by Earley and Lind (1987), would have been preferable. The fact that we can use only one indicator for the decision commitment construct confronts us with an important weakness of the evaluation of the proposed model for knowledge integration.

From the mean values and standard deviations we can see that, as is true for the singular items, also most latent variables are positively skewed (see: Appendix 6). Mean values show that respondents reported participation to be generally equal, that they managed to gain a pretty good big picture, created common ground, that task conflict was low, relationship conflict almost non-existent, that they were pretty satisfied with their performance as a group, and, finally, that they felt quite committed to the decisions taken. The results of the mean comparison between the two conditions (tool vs. non-tool) can be seen in Appendix 8.

For a better understanding of the use and perception of the tool, we added some *quantitative and qualitative control questions* to the questionnaire, which can provide first indications. When asked to describe the two major advantages of working with the tool. People responded most frequently that the tool allows for gaining an overall idea, for keeping in mind

the global outlook, and for visualizing schematically the major issues of the topic and thus providing a useful summary (see: Table *2*).

ADVANTAGES	No.	DISADVANTAGES / DIFFICULTIES	No.
General Impression		***Hampered conversation process***	
• **practical/useful/effective**	**19**	• **loosing time (because of formulation problems, handwriting is more immediate), interruptions in conversation flow**	**10**
• **simple & easy to use**	**18**	• low correspondence between what is said in discussion and what then has to be filled in on tool (use the tool after the discussion)	1
• immediate, quick	4	• breaks in conversation	
• open, generic, flexible	4	• **person who handles mouse is out of discussion and distracted (unequal participation)**	1 **5**
• colored	2		
• innovative	2		
Provides big picture (overview and precision in detail)		***Difficulty to adapt to predefined categories, modes of thinking, and format***	
• **allows for gaining overall idea/global outlook/summary (schematic visualization of major points)**	**20**	• **being forced to reason in the provided limited categories and metaphors - lacking flexibility**	**5**
• **helps to stay in the discussion "great for knowing what we are talking about and where we are going"**	**7**	• packed templates do not provide enough space	3
• helps not to loose track of the objectives of the discussion	1	***Excessive focus on technology***	
• allows for major precision	1	• handling problems due to low acquaintance with software	2
Provides structure		• focus on the tool instead of looking at the group members	3
• **turns issues explicit and clear**	**12**	• too much concentration on the tool instead of on the task (focus on the how (how to approach issue) rather than the what)	3
• provides clear categories and structures	3	***Forced consensual representation***	
Provides flexible persistence		• being forced to write also the aspects on which the group has not found a consensus	1
• gives possibility to cancel, change and update with the unfolding of the conversation	3		
• documents the findings and decisions taken	3		
• helps to remember precedent decision	1		
• simplifies the reaching of conclusions	1		
Provides common ground			
• provides common ground "everybody has got the same in front of the eyes"	2		
• offers common discussion structure	3		
• unifies	1		
• facilitates sharing of information	1		
Fosters reflection and changes in perspective			
• activates reflection	1		
• fosters alternative perspective in thinking	1		
Supports the simultaneous juggling of large amounts of information items			
• allows for having at disposition all the information	2		
Fosters commitment			
• allows for major concentration and commitment of all group members	2		

Table 2: Results of the Two Open-Ended Qualitative Questions: "What are the two major advantages/disadvantages of the use of the visual tool during the exercise?"

Note: No. indicates for the numbers of times a specific answer was given

In contrast to these positive quotes, 33% of the respondents felt that the tool was an obstacle for the flow of the conversation and almost 30% said that it hindered an equal participation at the conversation (cumulative percentage of respondents who answered with "strongly agree" or "agree"). People reported that the handling of the tool made them loose time (formulation problems) and interrupted the flow of the conversation (see: Table *2*). In addition, the person handling the tool became either very dominant in the conversation or acted as being relegated to the silent secretary that takes minutes. Spending time on detailed discussions how to word an issue certainly is problematic for maintaining the big picture. One reason for this sensation of loosing time with the handling of the tool can stem from the interlocutors' relative unfamiliarity with the tool. As discussed earlier (see: Pretest), we tried to assure a sufficient familiarity with the tool in various ways. First, the tool is quite easy to use and resembles in its mode of operation very common software programs (i.e. drag and drop). Second, students had to do an individual exercise with the tool prior to the experiment for a first familiarization. Third, the members of each group could decide themselves who should be appointed with the role of handling the tool during the discussion. It is therefore most likely that they have chosen a person who is quite adroit in handling software instruments. In spite of all these facts, students might have known the functionalities of the tool, but nevertheless not have felt very familiar in using the tool. In fact, observing the adoptions and appropriations of the tool (DeSanctis & Poole, 1994) were quite insightful. Most groups used only a very limited range of the functionalities the tool offers. Many, for example, did not work with colours for clustering, they did not use the comments for adding more detailed information and did not add new textboxes. In addition, groups differed quite significantly in the way they used the tool. Some drew on it while conversing as an ongoing visualization of what was discussed; others used the tool only every five minutes as a summary device. In this latter case, it is clear that using the tool interrupts the conversation flow. Similarly, some groups gave the tool-handler more autonomy and let him/her document the conversation rather quickly, others decided in rather long collective processes what to write and how to formulate each single statement. While each form of adoption has its advantages (e.g. collective formulation might turn tacit misunderstandings or task conflicts more apparent), it is most likely that the groups had not found out yet how to best make use of the tool. *Familiarity with the tool* might therefore be an important issue when stating that the tool hampered the conversation process. In spite of these reservations, only 9% of the respondents stated that they would have preferred to complete the task without the tool and only 11% reported that the tool added complexity to the task. Similarly, some people felt uncomfortable to reason in the provided categories, metaphors and per-

ceived those as an inflexible additional structure to the task. The perception of additional complexity is correlated to the impression that the tool hampered an equal participation (.71*). Secondly, individuals who reported that they were used to solve case studies, tended to state also that they would have preferred to work without the tool (correlation of .64*). It seems that if individuals were familiar with the kind of task, they did not need the structure the tool provides and perceived it therefore as less useful.

Finally, we controlled for satisfaction with performance using 3 items of Murthy and Kerr's (2003) four item scale (one item was specific to their research context). Satisfaction with performance measures the positive feelings and attitudes members of a group have toward a decision taken or a performance reached by the group (Keyton, 1999). Satisfaction is an important control variable out of various considerations. Previous research could show that the sharing of information leads to a greater group member satisfaction (U-shaped relationship: Mennecke, 1997), that there is also a positive relationship between members' participation and satisfaction (Fisher & Ellis, 1990; Olaniran, 1996), but that both content and relationship conflict lead to less satisfaction (De Dreu & Weingart, 2003). Knowledge integration, as we have conceptualized it, involves equal participation, the exchange of information, but also the examination of this information with a constructive level of conflict. For this reason, it is particularly interesting to measure this outcome variable as a control measure[5]. We found, comparing the tool with the non-tool condition, that there is no significant mean difference between the two conditions. Pearson correlations show that the satisfaction with the group performance positively correlates with the creation of the big picture (.70**) and with the creation of common ground (.52*) and negatively with relationship conflict (-.40*). The creation and perpetuation of the big picture in a conversation seems thus to be an important aspect for the satisfaction with group performance and has to be further researched in future studies. With regard to equal participation and content conflict, we were not able to confirm findings of previous studies as we did not find significant correlations between these constructs and the satisfaction with the group performance.

In summary, from the first descriptive and factorial analysis, we have gained the following insights. The descriptive analysis has shown that we have slightly abnormal distributions both on the level of the items as for the latent variables. Conducting the factorial analy-

[5] Other outcome variables like decision quality are more problematic to a study, which works with a preference task and which views communication not simply as a medium for decision making or knowledge integration, but as the constitutive element of these processes (Poole & Hirokawa, 1996).

sis, we were able to confirm many of the original scales we used in the questionnaire. Only for the constructs of equal participation and decision commitment, we had to adjust the originally proposed scales. Finally, the discussion of the qualitative questions has shown that conversation partners using the visual tool perceived it as helpful and easy to use and that it allowed them to more easily gain a global overview on the topic, as well as making issues explicit. Problematic was though that the tool forced them to spend a lot of time on formulating and documenting and stopped the natural conversation flow. Such drawbacks are most likely to be lessened once the conversation partners are more familiar with the tool.

In the following, we will present our structural analysis of the knowledge integration model and later discuss the moderation effect of the software based visualization tool.

Structuration Analysis: Testing the Knowledge Integration Model

The structural analysis is geared towards the evaluation of the following two claims. First, we aim to evaluate the proposed model for knowledge integration (hypotheses H1-H5) and, second, we want to test the hypothesis whether the interactive visualization tool has a moderation effect on the relationships of the model for knowledge integration (Hm1-Hm4).

Before presenting the results of the structure equation modelling analysis, Table *3* presents the inter-construct correlations of the latent variables.

	EP	BP	CG	TC	RC	DC
Equal Participation (EP)						
Big Picture (BP)	.36**					
Common Ground (CG)	.31*	.34**				
Task Conflict (TC)	-.33**	-.20	.07			
Relationship Conflict (RC)	-.19	-.31*	-.22	.26*		
Decision Commitment (DC)	.21	.38**	.04	-.38**	-.15	

Table 3: ***Pearson's Inter-Construct Correlations***

** Significance at .01 level, * Significance at .05 level

Various correlations are insignificant and the significant ones show low correlations ($0.2 < r \leq 0.5$). In view of our proposed second order reflective model, low correlations among the reflective constructs are expected (Edwards, 2001; Edwards & Bagozzi, 2000).

Figure 10 shows the results of the structure equation analysis we have conducted with the help of the software package Amos 6.

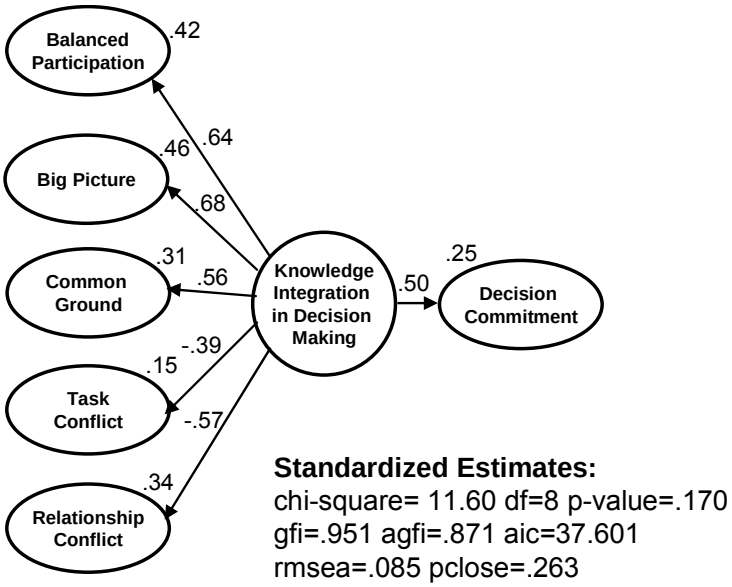

Figure 10: Results of the Structural Equation Analysis for the Knowledge Integration Model

Overall, the general model of fit measures are positive. We have satisfactory results for AIC (37.601) and CAIC (78.666), as well as for BCC (40.851) and BIC (65.666), as their numbers are lower for the default model than for the saturated model. These information theoretical measures are most important to confirm our model for knowledge integration, given the non-randomized selection of the sample. With regard to the descriptive measures, the GFI (0.951) is higher than 0.95, and AGFI (0.871) misses for a few points the 0.9 threshold. Furthermore, the chi-square (11.601) in relation to the degree of freedom (8) indicates a good model of fit, even a slight overfit. Finally, the measures of approximate fit, pclose (0.263, should be above 0.5) and RMSEA (0.263, should be smaller than 0.05) are not satisfactory.

The small degree of freedom shows the limited power of this first test of the model. MacCallum and colleagues, for example, argued, that when *the degree of freedom* is small, the confidence intervals will be very wide and the test will be subject to considerable imprecision unless N (the sample size) is extremely large. According to these authors, with a degree of freedom of 8, a sample size of 954 is needed in order test for close fit and achieve a power of 0.80 (MacCallum et al., 1996). In view of the very limited power of this first empirical test, the most important measures of model fit indicate to tentatively confirm the model, while other important ones (such as pclose and RMSEA) remind us to remain cautious.

Before discussing the model in more detail, one comment on a measurement level is necessary. We needed to introduce one *residual correlation* (of 0.46) between common

ground and task conflict in order to obtain the reported results. Apparently, people perceive a positive connection between task conflict and common ground. As we have mentioned earlier, task conflict can, under specific circumstances, lead to a more in-depth and richer understanding of the issue (Eisenhardt et al., 2000). While arguing on a content level, interlocutors develop a richer common ground among them. This conceptual connection explains why we can have residual correlations between the two constructs.

Figure 10 shows that the *latent variables reflecting knowledge integration* are all – with the exception of task conflict - *going in the direction we have claimed*: equal participation, big picture, and common ground reflect knowledge integration positively, while relationship conflict reflects it negatively. Again with the exception of task conflict, we have satisfactory coefficients for the loadings (above 0.5) and the variances explained (above 0.3) for all the latent variables. Most important for knowledge integration and most positively related is the big picture construct (with a loading coefficient (L) of 0.68 and an explained variance (EV) of 0.46) (H2 supported). Equal participation (L= 0.64, EV= 0.42) is similarly important (H1 supported), followed by common ground (L= 0.56, EV= 0.31) (H3 supported). This means that if conversation partners manage to create and maintain a big picture over the decision that has to be taken, i.e. they know how single aspects and contributions relate to the more general issue and do not get lost in discussions on details or irrelevant side-issues, then one can be pretty confident that they manage to integrate their knowledge. Yet, also common ground and equal participation are important reflections of the whether knowledge integration has taken place. On the other hand, as expected, relationship conflict reflects knowledge integration negatively (L= -0.57, EV= 0.33). Regarding the second phase of knowledge integration – the integration of the group knowledge into the decision making process – we equally have satisfactory results with a coefficient of 0.50. Yet, the explained variance of 0.25 is fairly low. A successful first-phase integration of individual knowledge into group knowledge explains only a fourth of why people feel committed to a decision (H5 weakly supported).

The results for *task conflict* did not meet our previsions entirely. We have made the hypothesis of an inverted U-curve relationship between task conflict and knowledge integration and have claimed that a moderate level of task conflict positively reflects knowledge integration. As mentioned earlier, we have operationalized this curvilinear relationship by squaring the task conflict concept (Backhaus *et al.*, 2003). Yet, even when modelling such a curvilinear relationship, we find a negative coefficient of -0.39 (which is, as expected lower than for relationship conflict). In addition, task conflict explains only 15% of the variance of

knowledge integration. Testing for the alternatively possible linear relationship, we find a -0.45 loading coefficient with an explained variance of 0.20. We interpret these findings that even a low or moderate level of task conflict reflects knowledge integration negatively and that a negative linear relationship is more likely (together with positive results for relationship conflict, H4 is supported). This finding stands in line with the recent quantitative meta-analysis on the literature on task conflict of De Dreu und Weingart (2003). In contrast to the general view of the positive effects of a moderate level of task conflict and the negative ones of relationship conflict, De Dreu and Weingart showed that task conflict actually has strong, negative effects on team effectiveness. They found this result to be true even if the correlation between task and relationship conflict was low. They concluded, conflict should not to be considered inherently as non-functional, rather, future research should study the circumstances, in which conflict can have positive consequences (De Dreu & Weingart, 2003). It will therefore be particularly interesting to see whether the use of the tool creates a circumstance, in which the relationship of task conflict and knowledge integration is less negative or even positive.

Testing the Moderation Effect of the Interactive Visualization Tool

The general aim of this second structure equation analysis is to show that, introducing a group comparison, we obtain a better model fit for knowledge integration and that we have a significant moderation effect on a relationship level of the model. In other words, we will show that conversation partners, interacting with the support of a visual tool, rely in their attempts to integrate knowledge more on the establishment of the big picture and the common ground, and less so on conflict.

First, introducing a group comparison in the structure equation analysis (tool versus non-tool), we actually find better overall model of fit measures. The information theoretical measures, (AIC 68.176) and BCC (83.343) are lower for the default model than for the saturated model. The descriptive measures, GFI (0.923) is over the 0.9 margin, not so, for a few points, AGFI (0.798). The chi-square amounts to 16.176, which results in a slight overfit in relation to the degree of freedom of 16. The important measures of approximate fit, pclose (of 0.600, should be and is above 0.5) and RMSEA (of 0.013, should be and is smaller than 0.05), show also satisfactory results. We find that, controlling for the tool use, we have better overall model fit measures and that there are actually structural differences how people integrate their knowledge when conversing in the unsupported or visually supported condition.

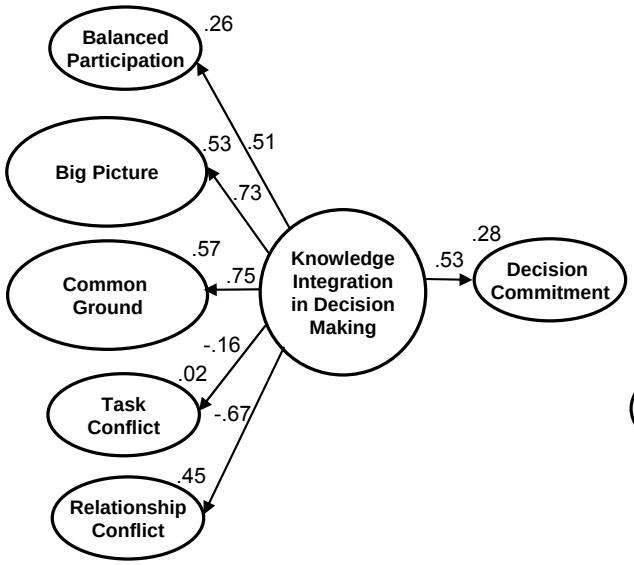

Figure 11: Knowledge Integration for Groups Interacting with the Support of the Visual Tool

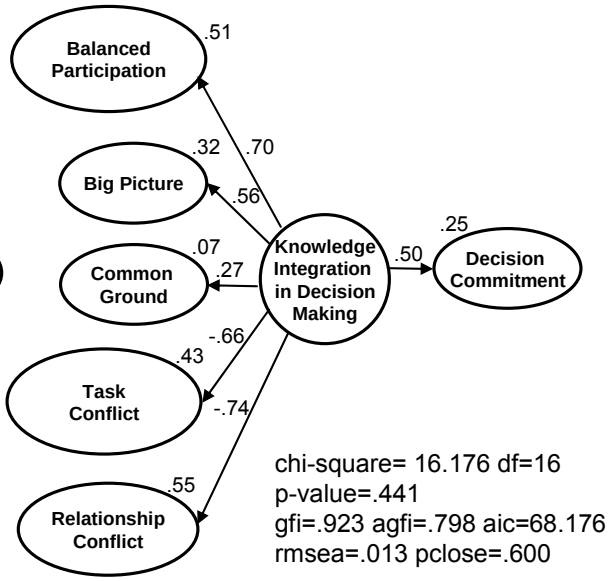

Figure 12: Knowledge Integration for Groups Interacting without a Visual Support

Second, we find a *significant moderating effect of the use of the interactive visual tool on our model for knowledge integration* (with a p of 0.010). *Figure 11* and *Figure 12* show the single coefficients and explained variances for the knowledge integration model, both for the tool and non-tool condition. Comparing the loading coefficients and the explained variances among the two situations, we can see that people, in the tool condition, rely mostly on the creation of a big picture and a common ground to integrate their knowledge and much less on equal participation and conflict. In the non-supported situation, the image is reversed: interlocutors account to a great extent on equal participation and conflict to integrate their knowledge and less so on the creation and perpetuation of a big picture and a common ground. Since conflict is reflecting knowledge integration negatively, we can say that in the non supported condition, interlocutors have more difficulties in integrating their knowledge. To visualize this overall finding of a parallel reversed image between the two conditions, we have drawn the sizes of the circles around the constructs corresponding to their importance for knowledge integration (see: *Figure 11* and *Figure 12*).

In more detail, we can observe the moderation effect of the tool most dramatically in the changes between *common ground* and *task conflict*. In the tool supported situation, common ground loads with a coefficient of 0.75 and explains 57% of the variance of knowledge integration. Task conflict, on its part, plays absolutely no role for knowledge integration. Its loading is still negative, but very low (-0.16) and it does not account for any variance in knowledge integration (0.02). On the other hand, in the non-supported condition, the situation

is exactly the opposite. Here, common ground does not explain knowledge integration in any way (low loading of 0.27 and very low explained variance 0.07), yet the impact of task conflict is strongly negative (loading of -0.66) and the explained variance is considerable (0.43). From these findings, we can infer that when lacking common ground, people start arguing about the issue when they attempt to integrate their knowledge. The tool facilitates the establishment of a common ground between the participants of a conversation, which makes task conflict become less important for the interlocutors' endeavours in integrating their knowledge.

Another interesting finding regarding the reversed picture and the relationship between common ground and task conflict is that respondents perceive a conceptual proximity between the two constructs only if they are supported by the tool. While in the general model, we have found *correlations between the residuals* between common ground and task conflict, the group comparison shows that, in the non-tool condition, the correlation is of only 0.14, whereas in the tool condition, the correlation is 0.61 high. We have argued that people perceive these two constructs to be interrelated in the sense that task conflict can - under specific circumstances - lead to a deeper understanding of the issue and to a greater common ground. For the interlocutors interacting without the visual tool, the condition is not given for that they conceptually interlink task conflict to common ground. This gives us a first indication on the hypothesis that the tool use supports a constructive handling of conflict.

We have claimed that *constructive conflict* is defined by three conditions: 1. a moderate task conflict; 2. a low relationship conflict; 3. a low correlation between task and relationship conflict. Comparing the model for knowledge integration between the two groups, we can find that, next to the already discussed differences concerning task conflict, relationship conflict loads strongly negatively on knowledge integration in both cases. In the tool supported situation, the loading coefficients and the explained variances are to some extent lower, but we can say that the use tool limits, but does not eliminate relationship conflict to be a negative cause of knowledge integration. What about the correlation between task conflict and relationship conflict? Conducting a correlation analysis in SPSS comparing between the two groups, we find, in the non-supported condition, that task conflict and relationship conflict are significantly positively correlated by a coefficient of 0.50**. On the other hand, if interlocutors are supported by the visual tool, there is no significant correlation between the two constructs (Pearson's correlation coefficient: 0.05 n.s.). This means that, for the interlocutors interacting without the support of the visual tool, whenever they perceive a task conflict, they also per-

ceive a relationship conflict. The interpretation is likely that, without a visual support, whenever conversation partners perceive content conflict, they understand it on a relational level, feel attacked personally and react on a personal level. Alternatively, it could also be that, in the non supported condition, interlocutors instrumentally use task conflict to fight out relational tensions among them. In both cases, a constructive handling of conflict is not possible. In sum, we can say that the use of the visual tool permits conversation partners to deal more constructively with conflict: first of all, it cancels out the commingling of task conflict and relationship conflict. Secondly, the weight and negative impact of relationship conflict can be lowered. Finally, we have found that also a moderate task conflict does not reflect knowledge integration positively. Yet, we have seen that, in the tool condition, task conflict does not play an important role for knowledge integration. Its role is positively substituted by the successful establishment of a common ground and, as we will see in the following, by the creation and perpetuation of the big picture.

For conversation partners interacting with the support of the tool, creating and sustaining the *big picture* is much more central for knowledge integration than for those interacting in the natural condition. In fact, in the tool condition, the big picture construct loads with a coefficient of 0.73 on knowledge integration and explains 53% of its variance. In the non-tool condition, it loads with a lower coefficient of 0.56 and explains the variance only by 32%. This confirms our hypothesis that the tool facilitates the perpetuation of the big picture since the tool helps conversation partners to better tackle the difficult balance between detail and general overview: it provides a dynamic visual summary so that interlocutors can position the main arguments, findings, questions that are emerging in the conversation, but can also deposit more detailed considerations thanks to the comment function.

With regard to balanced participation, we see an opposite trend. While in the tool condition, equal participation loads with .51 and explains 26% of the variance of knowledge integration, in the non-supported condition, it loads with a high coefficient of .70 and accounts for 51% of the variance of knowledge integration. As we have stipulated, equal participation remains important in both conditions. Yet, if conversation partners are not supported by an interactive visual tool, they are more sensitive to interactional justice (Bies & Moag, 1986) and attribute more importance to equal participation for the integration of knowledge. On the other hand, if they are supported by an interactive visual, it is easier for them to see which aspects receive less attention and still need to be discussed, which areas have to be developed further and for which aspects they have already found a sufficient agreement. They might be focused

more on what is said rather than on who says what. For this reason, the equal participation of all interaction partners becomes less central in the tool condition.

We have argued that knowledge integration is a two phase process, in which, first, the specialized knowledge of the individuals has to be integrated into a group knowledge, and then secondly, knowledge has to be integrated and transformed to the decisions to be taken. First, conversation partners share their insights and their specific perspectives on an issue and develop a more complete understanding of it. Once they have developed such an understanding, they have to integrate and apply it in the decisions and actions to be taken. We have said that we measure this second phase of the integration process with the construct of decision commitment. We have claimed that if the participants of a conversation are successful in the first phase of the integration process, this would lead to a better integration in the second phase and thus to a better commitment to the decision taken. We were able to show above that in the tool condition, conversation partners were more effective in integrating their individual knowledge into a group knowledge, which is why we also expected a better integration into decision making in the second phase, i.e. a stronger correlation with decision commitment. Yet, the numbers show that the correlation is more or less the same for the two situations. For the tool condition, we have a loading coefficient of 0.53 and an explained variance of 0.28. Similarly, in the unsupported condition we have slightly lower L (0.50) and EV (0.25). Working with the tool in the decision making process does not make people feel more committed to the decisions taken. We can conclude that the work with the visual tool supports the first phase in the knowledge integration process (the integration of specialized individual knowledge into group knowledge) as it facilitates big picture and common ground, but it seems not to facilitate the application of this knowledge into decisions and actions.

Implications, Conclusions & Limitations

In this final section, we review the central contributions and limitations of this paper. Understanding knowledge integration as a communication process, we have understood its challenges to be equally communicative and have defined – on the basis of existing literature and three explorative case studies – a communicative model for knowledge integration. Consequently, we have argued that the modality of communication changes the importance of the constitutive elements – equal participation, big picture, common ground, constructive conflict - of the model. In particular, we have claimed that interactive visualization can facilitate the communication across knowledge boundaries as communicators rely in their integration ef-

forts more on the facilitated construction of common ground and big picture, manage to deal with conflict more constructively, and are less sensitive to interactional justice (Bies & Moag, 1986) such as equal participation.

The aim of the empirical part of this article has been twofold: 1. provide a first empirical support for the model of knowledge integration in decision making, and 2. test whether the mode of communication moderates the way people integrate knowledge, more specifically, test whether supporting conversations by interactive visual tools motivates conversers to adapt a different strategy to integrate knowledge and rely less on equal participation and conflict, but on the establishment of common ground and big picture.

With regard to the first point, we found support for the presented reflective model for knowledge integration. In particular, we could confirm hypotheses H1, H2, H3, H5, and partially confirm H4. Only with regard to constructive conflict, our hypothesis (H4) could not be confirmed entirely. We found that while relationship conflict does reflect knowledge integration negatively, a moderate task conflict does not reflect knowledge integration positively (confutation of inverted u-curve hypothesis). This is an interesting finding also for the established discourse on conflict in decision making as it contradicts the long held belief that content conflict can have a positive effect on decision making (result, which finds support by the meta-study of De Dreu & Weingart, 2003). One minor limitation of the model is, in addition, that although the results for decision commitment are positive (H5), the first phase of integration (when the specialized individual knowledge is integrated to a group knowledge) explains only 25% of the variance in decision commitment. Although the aim of this study was not to provide an exhaustive explanation for decision commitment, we have to acknowledge that the integration of individual knowledge into group knowledge accounts for relatively little and that our support for the second phase of knowledge integration (integration of group knowledge into actual decision making) is not very strong.

With regard to the use of interactive visuals to support face-to-face conversations, we have found that the modality of the communication has an impact on the presented model for knowledge integration on a structural level and we could confirm all four moderation hypotheses Hm1 - Hm4. If the conversers lack the common ground among them and the big picture of the issue, then they are more sensitive to equal participation in their knowledge integration efforts and rely more on conflict. Yet, they are not able to constructively deal with conflict, which is why their attempts to integrate knowledge are less successful. In fact, we could show that in the situation where people interact without a visual support, not only both task conflict

and relationship conflict strongly negatively reflect knowledge integration, also do task conflict and relationship conflict significantly correlate with each other and conflict cannot be handled in a constructive manner. Supporting conversers through an interactive tool helps them to gain the big picture on an issue, establish a common ground and to more constructively deal with conflict. Next to these positive accounts of the use of cooperative visual tools, we have equally discussed some drawbacks: It can interrupt the flow of the conversation when the moderator needs to document what has been discussed and the group waits for him to have finished. This aspect depends on the skills of the moderator and his familiarity with the tool. The work with the tool can also add complexity to the task by imposing an additional analytic frame, which further might be lived by conversation partners as limitative and adding a rigid frame of thinking. There might be additional problems related to the use of the visual tool for the integration of knowledge, which are not so easily observable by conversation partners. Visualization leads to a reification of abstract concepts in perceivable objects. This might facilitate, on the one hand, understanding, on the other, it can aggravate the tendency of people to cling to an inappropriate mode of approaching an issue (Eppler, 2003) and impede perspectives changes.

Overall, the results from the group comparison suggest that there are important *dependencies among the various constituting elements of knowledge integration*, which we upfront conceived as independent. When presenting the model for knowledge integration, we have identified four major communicative challenges present when experts interact with decision makers and aim to integrate knowledge in the decision process. Yet, we have not discussed eventual correlations amongst the various challenges. On the basis of the present literature and the insights we gained from the explorative case studies, we believe that it is already a step to isolate some key knowledge integration challenges and gain an understanding of their importance for the phenomenon. The numbers of the group comparison (visualization support/natural condition) then has shown an exactly reversed picture in the two conditions and has led us interpret the data in a direction where dependencies among the major four knowledge integration challenges are assumed: At the absence of a sufficient common ground and at the lack of a big picture of the issue, conversation partners compensate with conflict and become highly sensitive to equal turn taking. These interpretations are somewhat daring as we have just observed a decline/increase of certain constituting elements of knowledge integration, but have not actually tested for their dependence. Future research should therefore be more explicit about the interrelationships among the elements, which constitute the knowledge integration process. Our interpreted interrelationships are also still somewhat unspecific and

future research should analyze more precisely whether it needs the creation of both big picture and common ground conjointly for that conflict becomes less important in the knowledge integration process or whether one of them is sufficient.

A second limitation of the presented model for knowledge integration in decision making is generally true for models and is that it *is not comprehensive and misses out variables* that are might be crucial for the explanation of the phenomenon. One such variable could be the degree of novelty and variability inherent within the decision to take or task to confront. Scarbrough et al. for example state that the higher the novelty or uniqueness of a project task, the higher is the potential but also challenge for knowledge integration (Scarbrough et al., 2004). Similarly, Carlile refers to the knowledge's nature of being path-dependent, which makes it particularly difficult for interlocutors to give up their knowledge and accept or develop new knowledge: "The most challenging aspect of the relational nature of knowledge at a boundary is that for each actor there is novelty to share with others and novelty to assess from others" (Carlile, 2004: 557). Next to this aspect of novelty, there are other aspects that we have not taken into account. These might not be directly related to the communicative situation of experts and decision makers, but are present in the organizational context and have an influence on the interaction. Alavi and Tiwana for example discuss the inflexibility of organizational ties, which represents a challenge to knowledge integration efforts (Alavi & Tiwana, 2002). Hargadon and Sutton (2000) mention the rate of employee turnover to be another challenge for knowledge integration and which in fact is an element that impacts on the challenge of establishing a common ground. In this way, there are various extensions possible for the model of knowledge integration we have presented. Yet, we have outlined that the model presented is a communicative model and aims to capture only the interactional, communicative challenges present at a knowledge boundary. In this way, its focus is more micro and it deliberately misses out larger organizational aspects already fairly well discussed in the organizational literature (De Boer et al., 1999; Dougherty, 1992; Eisenhardt & Santos, 2000; Grant, 1996a; Huang & Newell, 2003; Ravasi & Verona, 2001; Scarbrough et al., 2004). We have argued that if we adopt a relational, contextual, practice-bound understanding of knowledge and if we agree that knowledge is created, shared, integrated, or applied in social interactions (Nonaka & Takeuchi, 1995), it is important to study the communicative challenges present in the primary form of these interactions, which are conversations. In this way, the presented model on knowledge integration represents an attempt in this direction. It singles out major obstacles that are present in conversations and which inhibit the integration of knowledge across knowledge boundaries. Future research could aim to address more specifically the inter-

relationships of such micro-communicative challenges with more macro-organizational aspects that challenge the integration of knowledge in decision making.

Next to these limitations regarding our model, this study also has several limitations regarding its methodology. First and foremost, we have mentioned the small N of our data for conducting structure equation modelling analysis and we have discussed the limitations this poses to the external validity and robustness. Second, we have seen that the respondents were only semi-familiar with the visualization tool in spite of the pre-arrangements we have made (presenting students the use and functionality of tool, making them work with the tool for a course exercise prior to the experiment). Third, the hidden profile situation might lead to an information difference, but not to a true difference of knowledge within the group. The in-depth knowledge of a knowledge management expert and the mode of thinking of a decision maker cannot be simulated fully in this way. Forth, the reliability of self-reporting (through questionnaires) on conversational processes is questionable in so far as conversation partners are not fully aware of their conversation behaviour and there might be important differences between their espoused theories (self-descriptions of one's behaviour, values, beliefs) and the ones in use (more implicit values, beliefs, and assumptions manifested in practice) (Argyris & Schön, 1978). Finally, a general critique on the experimental design we have used is that we have worked with students as respondents for the experiment (Gordon *et al.*, 1986).

Future research can address these limitations in various ways. The experiment could be replicated by using – instead of students - two groups of professionals, between which a clear difference in specialization exists and can be assessed through knowledge tests and tests of thinking styles (Sternberg, 1997). Researchers could combine methods that rely on self-reporting and those that permit observation of communicative behaviour directly. Questionnaires could be complemented by recorded conversation analysis. To address the important issue of tool familiarization, more embedded and longitudinal studies have to be conducted. Scholars would study in a mid-timeframe how collaborative visual tools are appropriated by certain organizational teams or departments. They would also have to examine whether a recurring use of the tool would lead participants of a conversation to change their way they deal with the identified challenges of knowledge integrating conversations, such as equal participation, common ground, big picture, or constructive conflict. In addition, institutional aspects such as are discussed in Orlikowski and Barley (2001) have to be considered and need to be further investigated in future research endeavours.

Finally, *practitioners* and decision support developers can gain the following insights from this study. First, we have seen that even simple tools need a certain time for appropriation and familiarization. The benefits that a collaborative visualization tool can provide for a decision making meeting depend on the skills of the facilitator using it. If he/she is capable of summarizing a five minute conversation on a certain issue in one sentence and position it meaningfully in a visual template, the tool will not slow down the speed of the conversation, but help to structure it and help interlocutors in creating the big picture of an issue. Practitioners, who want to introduce a new collaboration technology in their organization, are therefore well advised to introduce the technology together with a meeting facilitator, who is not only trained in the functionalities of the technology, but who is also knowledgeable about meeting facilitation and who has a knowledge on which visual templates are useful for which task type. We have further learned from the qualitative and control questions that using a visual tool can not only facilitate knowledge integration in decision making, but that the provided visual frame can also add complexity to the decision task or provide a perspective, which is not always beneficial. In practice, a facilitator should therefore realize when to change from one visual template to another, or when to stop using the visual tool altogether. There are moments in a meeting or there are entire meetings, where the use of a tool is counterproductive and inhibits what Gratton and Ghoshal call the trust-building or emotional ‘intimate exchanges’ (Gratton & Ghoshal, 2002).

Appendix

Appendix 1: The Decision Maker Version of the Case Study

The Pragmatic Development and Use of Know-how: Knowledge Management *Light* at Securitech Ltd.

> "Knowledge is not only a decisive competitive factor for research-intensive, multinational corporations, but also for a smaller, know-how-dependent firm such as ourselves, which is now expected to win market share in supra-regional competition." Managing Director of Securitech Ltd.

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A The Business Context

Securitech Ltd. is a limited liability company headquartered in Zurich, which has been active in the areas of fire protection, break-in protection and corporate security for approximately 25 years. It was originally founded as an unincorporated company, and led by the company's founder for approximately ten years, until he sold it to the management team, which helped to expand the company from around eight to, now, over ninety permanent employees. For fifteen years, a team of six managers has led the firm, although half of these had been with the company for less than five years. Of Securitech's 95 employees, around 80 were directly involved in client projects. Securitech's client portfolio is centred around medium-sized and large industrial companies throughout the greater Zurich area, as well as in the neighbouring regions. These required advice and products for security systems in warehouses, production sites and offices. The range of services offered by Securitech runs from the simple installation of a fire alarm system or a security system to the integrated planning of a company security concept for crucial annex buildings or the handling of dangerous materials.

Securitech is organised into three profit-centre like sectors, i.e. fire protection and prevention, break-in protection and alarm systems, as well as integrated corporate security. In terms of turnover, the two first sectors each accounted for approximately 40 percent of the total. The remaining 20 percent from corporate security consulting, however, accounted for almost half of Securitech's profit. For this reason, the company's management had decided to more strongly accelerate growth in the area of integrated corporate security, not merely to continue as supplier and installer of security products, but to increasingly present itself as a competent corporate security consultant in the (supra-regional) market. A major obstacle in the pursuit of this strategy is, nevertheless, the relatively rigid profit-centre orientation of the majority of the employees, which is especially harmful to the sector-overreaching activities in the context of integrated corporate security. In addition Meyer, the technical director, had several times critically reflected on Securitech's learning capacity to the management, and ironically noted that "we call experience what we have been doing wrong for the last ten years – we don't really learn from our successes and failures." Most members of project teams, according to Meyer, "rush from one project to the next without looking right or left."

In addition to all this, it is just in the sector of integrated corporate security where the main know-how is concentrated in a few engineers, who are in great demand in the job market. Several departures of highly qualified employees in the past year hurt all three business sectors. One had the feeling that a large mass of project experience and technological knowledge has been lost in one go. At the same time, technological change is sweeping the security industry faster than ever before, and many employees expressed their difficulties in keeping up with the newest product developments (to say nothing of the reserve shown in the use of computers and related applications). On the client side, this occasionally leads to a lack of respect for the know-how of the Securitech security consultants, probably also because Securitech finds it difficult to properly show and market their wide range of knowledge regarding security concepts and technologies. Facing these challenges, Securitech has developed the vision to be a knowledge-based, learning organisation that is active on a supra-regional level and deals with significantly more complex projects.

* * *

B The Five Proposed Knowledge Management Activities

On the basis of this state of affairs, the managing director of Securitech decided that Furrer, an experienced project-manager of Securitech who already had developed various knowledge management activities in his former job, should work out – together with an expert in the field of knowledge management - five *light* but specific knowledge management measures. Furrer and the external expert would then discuss these measures with the two responsible members of the management. Together, they would decide, which three of the five measures they should actually implement. The following five proposals are under discussion:

1. Knowledge Architecture

This project envisions the creation of a *knowledge architecture* of the areas of Securitech's core competencies, for an improved positioning and marketing of the company's knowledge for client acquisition, but also for the recruitment of new employees. The planned graphic illustration aims to show how the different competencies of Securitech worked in unison, and how they were distributed within the firm (which sector has which know-how).

2. Know-how Organizational Chart

The *know-how organizational chart* sets up a type of "knowledge shadow organisation" that aims to improve the network of competencies within Securitech and to overcome profit-centre-based thinking. In addition, this measure is intended to determine responsibilities for certain technology areas ("who is a specialist and contact person in what area and documents it accordingly."). Additionally, this initiative is also intended to foster the concept of "communities of practice" within Securitech.

3. Knowledge Fair

The third proposed knowledge management measure consists of the organisation of a semi-annual *knowledge fair* with posters in the local cafeteria regarding important client projects, technologies and problems.

4. The Knowledge-Cockpit

The forth proposed knowledge management measure is a regular gathering of a *knowledge cockpit* by means of various indicators, for the unitary assessment (and early warning) of the state of Securitech's knowledge.

5. The Learning Curve

The *learning curve* project plans the organisation of regular lessons learned workshops for all large-project teams, to make the learning capital of the finished projects accessible to other employees.

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C Your Assignment

In a one hour meeting, Furrer and the external knowledge management expert have to present the five knowledge management measures they have elaborated to two members of the management. Furrer and his expert already know that there is a lack of funding for all five initiatives and only three of them will be pursued further. At the end of this meeting, the three most convincing projects will be determined and the action steps to implement them will be decided.

Imagine being part of this meeting: You take over the role of being a member of the management to whom the projects are presented. Your conversation partners are 1. another manager like you; 2. Furrer and; 3. the external knowledge management expert. During the one hour discussion you will complete the three assignments described below. Furrer and the external expert can inform you on how the five knowledge measures look like. On the other hand, you have the feeling that they still lack some important corporate information, you should share with them. As final result of the one hour discussion, hand in the 4 evaluation criteria, and the 3 chosen projects.

1. During the first 30 minutes, **define four criteria by which you will evaluate the knowledge management measures**. To do so, share with the two experts your information, insights and suppositions on the Securitech's vision and objectives, but also on its internal and external problems and challenges. Remember, you as the mangers have deep insights into the corporate situation of Securitech (its structure, problems and objectives). Actively share this corporate information with the experts, since it is very important in order to decide with what criteria you will evaluate the knowledge management measures. Thus, in order to define the assessment criteria for the knowledge management measures, consider the overall situation of Securitech, but also of what you have learned until now on knowledge or project management either in class or through you previous internships or working experiences.

2. During the next 30 minutes, **discuss the five planned knowledge management measures, evaluate them and decide which three of the five you actually want to implement**. Ask the experts to give you and overview on all five elaborated knowledge management measures, since you are informed on them on a very superficial level. Evaluate the proposed knowledge management measures on the basis of the four assessment criteria you have defined in the previous 30 minutes and decide which three you actually want to pursue further.

Appendix 2: The Expert Version of the Case Study

The Pragmatic Development and Use of Know-how: Knowledge Management Light at Securitech Ltd.

> "Knowledge is not only a decisive competitive factor for research-intensive, multinational corporations, but also for a smaller, know-how-dependent firm such as ourselves, which is now expected to win market share in supra-regional competition." Managing Director of Securitech Ltd.

A The Business Context

Securitech Ltd. is a company headquartered in Zurich, which has been trading in the areas of fire protection, break-in protection and corporate security for approximately 25 years. Securitech's clients require advice and products for security systems in warehouses, production sites and offices. The range of services offered by Securitech runs from the simple installation of a fire alarm system or a security system to the integrated planning of a company security concept for crucial annex buildings or the handling of dangerous materials. In the last years, the security industry is experiencing a technological change that is faster than ever before, and many employees have difficulties in keeping up with the newest product developments. For fifteen years, a team of six managers has led the firm, although half of these had been with the company for less than five years. Securitech has 95 employees and experienced quite a high employee turnover in the last years. Given the current situation, Securitech aims to be a knowledge-based, learning organisation that deals with significantly more complex projects.

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B The Five Proposed Knowledge Management Activities

On the basis of this state of affairs, the managing director of Securitech decided that Furrer, an experienced project-manager of Securitech who already had developed various knowledge management activities in his former job, should work out – together with an expert in the field of knowledge management - five *light* but specific knowledge management measures. Furrer and the external expert would then discuss these measures with the two responsible members of the management. Together, they would decide, which three of the five measures they should actually implement. The following five proposals are under discussion:

1 Knowledge Architecture

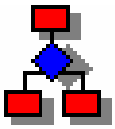
This project envisions the creation of a *knowledge architecture* of the areas of Securitech's core competencies, for an improved positioning and marketing of the company's knowledge for client acquisition, but also for the recruitment of new employees. The planned graphic illustration aims to show how the different competencies of Securitech worked in unison, and how they were distributed within the firm (which sector has which know-how).

1. Knowledge Architecture		
Logo: 	Benefit: The visual depiction of our core competencies and their interaction enables clients and new as well as potential employees to understand our know-how better. In addition, it will aid us in structuring the know-how organization chart (see 2).	Costs: One-off drafting by core team and graphic artist: approx. CHF 25,000
	Execution: Will be prepared/reviewed max. once per year	
Target group: All (potential and current) employees and clients		
Process: 1. Determination of our core competencies (integrated security planning, fire prevention, break-in protection, labour and production safety) during the next business management meeting with the participation of important experts (Frei, Sutter, Gerhardt) 2. Working out of interdependent and sub-know how areas 3. Presentation of competencies as an attractive map 4. Printing of respective posters, flyers 5. Notification of employees by superiors 6. presentation of the map in recruitment and sales discussions 7. Annual updating of the map as appropriate		
Documentation Posters and flyers will be filed in the L:/Knowledge/Architecture directory.		
Person(s) responsible: Anton Furrer		
Check: Measurement though poster distribution in canteen and presentation in every team. Use in sales situations.		

Furrer and the knowledge management expert plan to accommodate around twenty different sectors and sub-sectors of know-how with some measure of clarity in a diagrammatic depiction. Based on this arrangement, the aim is to create practice groups. Furrer is convinced that such a diagram of the knowledge architecture would make a notable impression at client meetings or recruitment sessions and that clients and competitors assessed it as professional, innovative or maybe even enlightening (in part because it could create a common context whereby it is possible to orient oneself in conversations and meetings). Yet, one fear of Furrer is that nobody in the Securitech Ltd would have the technical skills to actually draw the diagram. For this reason, they probably would have to work with an informational graphics specialist. Next to the rather high costs of such a person, the problem would be that this person, after drafting the knowledge architecture, most likely would know more about the know-how of Securitech AG than many employees, but would then leave the company with all its acquired knowledge.

2 Know-how Organizational Chart

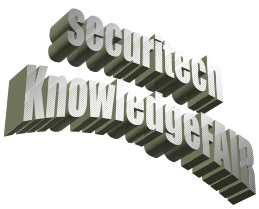
The *know-how organizational chart* sets up a type of "knowledge shadow organisation" that aims to improve the network of competencies within Securitech and to overcome profit-centre-based thinking. In addition, this measure has the aim to determine responsibilities for certain technology areas ("who is a specialist and contact person in what area and documents it accordingly."). Additionally, this initiative is also intended to foster the concept of "communities of practice" within Securitech.

2. Know-how Organization Chart		
Logo: **Securitech Know-how** 	Benefit: Allocation of responsibility for specific technologies or processes to designated employees ensures a secure basis for the building up of knowledge.	Costs: No quantifiable cash investment. Time investment of around 20 know-how area specialists: approx. 5 hours per week = approx. CHF 10,000 per week. (imputed costs)
	Execution: Regular screening of relevant trends as well as periodic briefings and reports to all employees by means of the employee newsletter or documents made accessible on the Server.	
Target group: Technology and process specialists of Securitech AG, as well as key account managers and project leaders.		
Process: 1. Extracting approx. 20 know-how areas from our knowledge architecture 2. Identification of relevant experts 3. Allocation of tasks and responsibilities among the experts 4. Experts organise practice groups and send initial orientation E-mail 5. Experts set up area on server 6. Five group leaders will present their area at the first knowledge fair (see point 3)		
Documentation The experts will set up their areas under L:/Knowledge/Groups.		
Person(s) responsible: Gregory Meyer: Head of production and technology		
Check: At least one technology report per know-how expert and year. At least two briefings to employees. At least two practice group meetings per year. Know-how-Organigram is available in the company presentation. Updates with Meyer.		

To draw up a knowledge structure and the relevant responsibilities would be relatively easily. However, Furrer's biggest concern with this initiative is that the specific actions would depend heavily on the individual expert leader so that, at the end, no actions actually would take place. Because of this risk, Furrer and his knowledge management expert are not quite sure whether it would be better to identify the "hot topics" and build on existing informal groups, instead of insisting on practice groups.

3 Knowledge Fair

The third proposed knowledge management measure consists of the organisation of a semi-annual *knowledge fair* with posters in the local cafeteria regarding important client projects, technologies and problems.

3. Knowledge Fair		
Logo: 	Benefit: Systematic and global knowledge transfer between the various project teams of all Securitech sectors.	Costs: Hall rental: CHF 700 Approx. 30 educational units: CHF 40,000 Other costs: CHF1,300. **Total** : approx. CHF 42,000 per year
	Execution: 1-2 times per year, in the form of a half-day event coupled with technical reports and case studies.	
Target group: All project leaders and project staff.		
Process:		

1. Preparation of posters by project teams to introduce their area of expertise 2. Submission of topics and clustering through Hurter => exhibition layout plan 3. Set-up of booths by operations department, invitations per memo by Furrer 4. Start: 8:30 am, two technical reports and subsequent holding of fair until 1:00 pm 5. Individual informational briefings in booths the whole morning. Short presentations in booths possible 6. Report on fair in employee newsletter by Hurter
Documentation
The posters of the project teams will be filed under L:/KnowledgeFair/ Year/Poster. The two introductory reports will be filed under L:/KnowledgeFair/Year/Reports.
Person(s) responsible:
Hans Hurter: assistant / project management support.
Check:
At least one general company meeting per year with attendance by at least 70 percent of project staff. At least one partial meeting with attendance by at least 40 percent of project staff.

Crucial for the success of the knowledge fair is the committed participation of the employees. For this reason, one of the challenging questions of this measure is how to ensure that all project teams actually produce a poster, that at least 70 percent of the project staff takes part in the knowledge fair and that the feedback questionnaire is completed by about two thirds of the participants. To have the necessary commitment of the employees, it is crucial that this measure would be well communicated. Furrer therefore thinks to create logos not only for this particular measure, but for all the knowledge management initiatives they will implement. Another important issue is also of how to organize the fair so that it becomes an event that not only is a tool to invite people to share their project experiences, but also increases the identification with Securitech as an organization and motivates the employees in their daily work.

4 The Knowledge-Cockpit

The forth proposed knowledge management measure is a regular gathering of a *knowledge cockpit* by means of various indicators, for the unitary assessment (and early warning) of the state of Securitech's knowledge.

4. Knowledge-Cockpit		
Logo: 	Benefit: Periodic success and risk vetting through a core set of meaningful indicators of knowledge increase and decrease, respectively knowledge use/development, at Securitech.	Costs: Data collection costs: 4 hours per department semi-annually: approx. CHF 15,000
	Execution: Semi-annually through all levels (from teams through departments and whole-business)	
Target group: All project leaders and project staff.		
Process: 1. Identification of critical knowledge areas (= target-determining) 2. Compiling indicators – modelled on 'balanced scorecard' – in business management meeting 3. Initial collection of indicator data and linking to Cockpit 4. Periodic data collection and analysis 5. Fine tuning and annual comparisons as the occasion arises		
Documentation Indicators will be maintained in the access database.		
Person(s) responsible: Max Baumer (CFO)		

Check:
At least one semi-annual run with 8 indicators from the areas of technology-know-how, client knowledge, profitability and processes.

When Furrer elaborated the proposal for this measure, he found it quite challenging to develop an adequate set of indicators. Too few indicators would not cover the various aspects, fields and uses of knowledge. On the other hand, too many indicators would be difficult to manage. Also, since the employees would be responsible for the data collection in their sector, Furrer fears that it would mean to ask them too much effort for this particular initiative. Therefore, the biggest challenge to implement this measure successfully probably is to develop a clever system of manageable indicators that might be structured along two dimensions. Two possible dimensions could be innovation and efficiency. The three indicators in the area of innovation could then be the so-called rookie ratio (the percentage of new employees, who had been with the company for less than one year), the new client ratio (percentage of new clients) and the new product ratio (percentage of new products on offer, i.e. which have been available for less than six months). The indicators in the area of efficiency could be the winning ratio (number of won clients in relation to submitted offers), the training ratio (number of diplomas received per professional examination taken) and the consulting ratio (percentage of consulting projects).

5 The Learning Curve

The *learning curve* project plans the organisation of regular lessons learned workshops for all large-project teams, to make the learning capital of the finished projects accessible to other employees.

5. Learning Curve		
Logo: 	Benefit: This systematic milestone-analysis will help the team to avoid repeating mistakes, improve processes and reduce unnecessary work/expenditure, as well as preserving important findings for the future.	Costs: Team meeting room, meta-planning tools and room. => Approx. 3 half-day workshops per year and team: no quantifiable cash costs, imputed costs approx. CHF 80,000 (to be charged to project budget)
	Execution: Approx. three times per year as a half-day event with presenter from another project group.	
Target group: All project leaders and project staff.		
Process: 1. Stakeholder analysis of the project 2. Survey of the most common questions, mistakes, successes, experiences with external contractors etc. 3. Process review (what went well, what didn't work => findings and actualisation) 4. Plan of measures to be taken 5. Looking forward 6. Documentation saved on L server		
Documentation The metaplan working papers of the project teams will be filed under the path name L:/Knowledge/Learningcurve. Where projects have been completed, a short case study will be produced and filed in the same directory.		
Person(s) responsible: Large-project leaders. Project management support Hans Hurter		
Check: At least one completely documented learning curve workshop per year / large-project team.		

Furrer and the knowledge management expert are quite confident that this project would become a success. What they still do not have clearly in mind is the way how they want to document the 'lessons learned'. A very handy

appraisal format would be determinant whether people who did not assist the workshops could actually learn from the lesson.

* * *

C Your Assignment

In a one hour meeting, Furrer and the external knowledge management expert have to present the five knowledge management measures they have elaborated to two members of the management. Furrer and his expert already know that there is a lack of funding for all five initiatives and only three of them will be pursued further. At the end of this meeting, the three most convincing projects will be determined and the action steps to implement them will be decided.

Imagine being part of this meeting: You will take over the role of either Furrer or the knowledge management expert. You will talk to two managers of Securitech Ltd., who only have a very limited knowledge on your initiatives. You as the experts are the ones who have deep insights on how the five knowledge measures look like. On the other hand, while you were elaborating the five knowledge management measures, you realised that you still lack some important corporate information. The mangers can provide you with that information. During the one hour discussion you will complete the two assignments described below. As a final result of the one hour discussion, hand in the 4 evaluation criteria, and the 3 chosen projects.

3. During the first 30 minutes, define **four criteria by which you will evaluate the knowledge management measures**. To do so, share with the two managers your information, insights and suppositions on the Securitech's vision and objectives, but also on its internal and external problems and challenges. Since you still lack some important information on these corporate issues, actively ask the managers to give you more insights on the specifics, problems and goals of Securitech. This information is important in order to decide with what criteria you will evaluate the knowledge management measures. Thus, in order to define the assessment criteria for the knowledge management measures consider the overall situation of Securitech, but also of what you have learned until now on knowledge or project management either in class or through you previous internships or working experiences.

4. During the next 30 minutes, **discuss the five planned knowledge management measures and evaluate them** so that the two managers can decide **which three** of the five **to actually implement**. Give the managers an overview on all five elaborated knowledge management measures. Remember, you as the experts have spent a lot of time developing these measures and know much more on the issue. You can contribute valuable insights and suggestions, but the decisions, which ones to pursue further are then taken by the two managers. For the evaluation of the measures, use the four assessment criteria you have defined in the previous 30 minutes. Let the two managers decide, which three knowledge management measures to pursue further.

Appendix 3: The Information Cues of the Expert and Decision Maker Versions of the Case Study

Information Cues	Expert	Decision Maker
Corporate Information Cues		
General		
• medium sized company (90 employees)	x	x
• new management team		x
Organizational Structure:		
• profit center: fire (40%), break in (40%), corp. Sec (20%)		x
Strategy:		
• grow in corporate security segment		x
• enlarge action scope from regional to supra-regional level		x
• establish vision to be a knowledge-based, learning organization that deals with significantly more complex projects.	x	x
Problems and Challenges:		
• learn few from past experiences (successes / failures)		x
• knowledge concentration in a few employees particularly in the corporate security business		x
• knowledge amnesia due to employee turnover	(x)	x
• profit center orientation -> particularly problematic for corporate security business		x
• poor marketing of expertise -> poor valuing of expertise on client side		x
• keeping up with fast technological change and quick product development	x	x
Project Information Cues		
Knowledge Architecture		
Logo	x	
Benefits:		
• improved positioning and marketing of the Securitech's knowledge for client acquisition, but also for the recruitment of new employees	x	x
• practice groups elaborating knowledge areas -> sensitization, coming together	(x)	
Drawbacks:		
• don't have skills within Securitech	x	
• hire expensive external person		
• loose knowledge when that external person has finished the job		
Cost: CHF 25'000	x	
Target: all employees		
Linkage to Other Initiatives: know-how org chart	x	
Implementation Process	x	
Documentation	x	
Person Responsible	x	
Output/Year: posters with graphical representation of knowledge architecture (electronic, physical)	x	(x)
Know-how Organizational Chart		
Logo	x	
Benefits:		
• improve the network of competencies within Securitech and overcome profit-centre-based thinking	x	x
• determine responsibilities for certain technology areas	x	x
• foster the concept of "communities of practice" and building a knowledge base	x	x
Drawbacks:		
• specific actions would depend heavily on the individual expert leader so that, at the end, no actions actually would take place	x	
Cost: CHF 10,000 per week (work hours)	x	

Information Cues	Expert	Decision Maker
Target: Technology and process specialists, key account managers and project leaders	x	
Linkage to Other Initiatives: (knowledge architecture)	x	
Implementation Process	x	
Documentation	x	
Person Responsible	x	
Output/Year: A knowledge shadow organization. Regular screening of relevant trends as well as periodic briefings and reports to all employees by means of the employee newsletter or documents made accessible on the Server.	x	(x)
Knowledge Fair		
Logo	x	
Benefits:		
• Systematic and global knowledge transfer between the various project teams	x	
Drawbacks:		
commitment of the employees -> good communication needed	x	
Cost: CHF 42,000	x	
Target: All project leaders and project staff	x	
Implementation Process	x	
Documentation	x	
Person Responsible	x	
Output/Year: semi-annual knowledge fair with posters in the local cafeteria regarding important client projects, technologies and problems	x	x
Knowledge-Cockpit		
Logo	x	
Benefits:		
Periodic success and risk vetting through a core set of meaningful indicators of knowledge increase and decrease, respectively knowledge use/development	x	
Drawbacks:		
• develop an adequate set of indicators	x	
• much effort asked from staff	x	
Cost: CHF 15,000	x	
Target: All project leaders and project staff	x	
Process	x	
Documentation	x	
Person Responsible	x	
Output/Year: set of meaningful indicators of knowledge increase and decrease, respectively knowledge use/development	x	x
Learning Curve		
Logo	x	
Benefits:		
• make the learning capital of the finished projects accessible to other employees	x	x
Drawbacks:		
• documentation of lessons learned	x	
Cost: CHF 80,000	x	
Target: All project leaders and project staff	x	x
Process	x	
Documentation	x	
Person Responsible	x	
Output/Year: regular lessons learned workshop (3xyear)	x	x

Notes:
x: information cue is fully and clearly available to the person with the specific role
(x): information is cue only indirectly and less explicitly available to the person with the specific role
text: information cue that is completely unimportant for the decision making process

Appendix 4: Overview on let’s focus suite

The *let’s focus Timeliner* is a tool that is thought to systematically structure conversations that aim at planning, documenting or reviewing processes. It contains four parallel time lines which can vary in their size and description. These streams can be structured into daily, weekly or monthly segments, and then filled with activities and events (let's-focus, 2006). Is suited for planning tasks (DeSanctis, 1987).

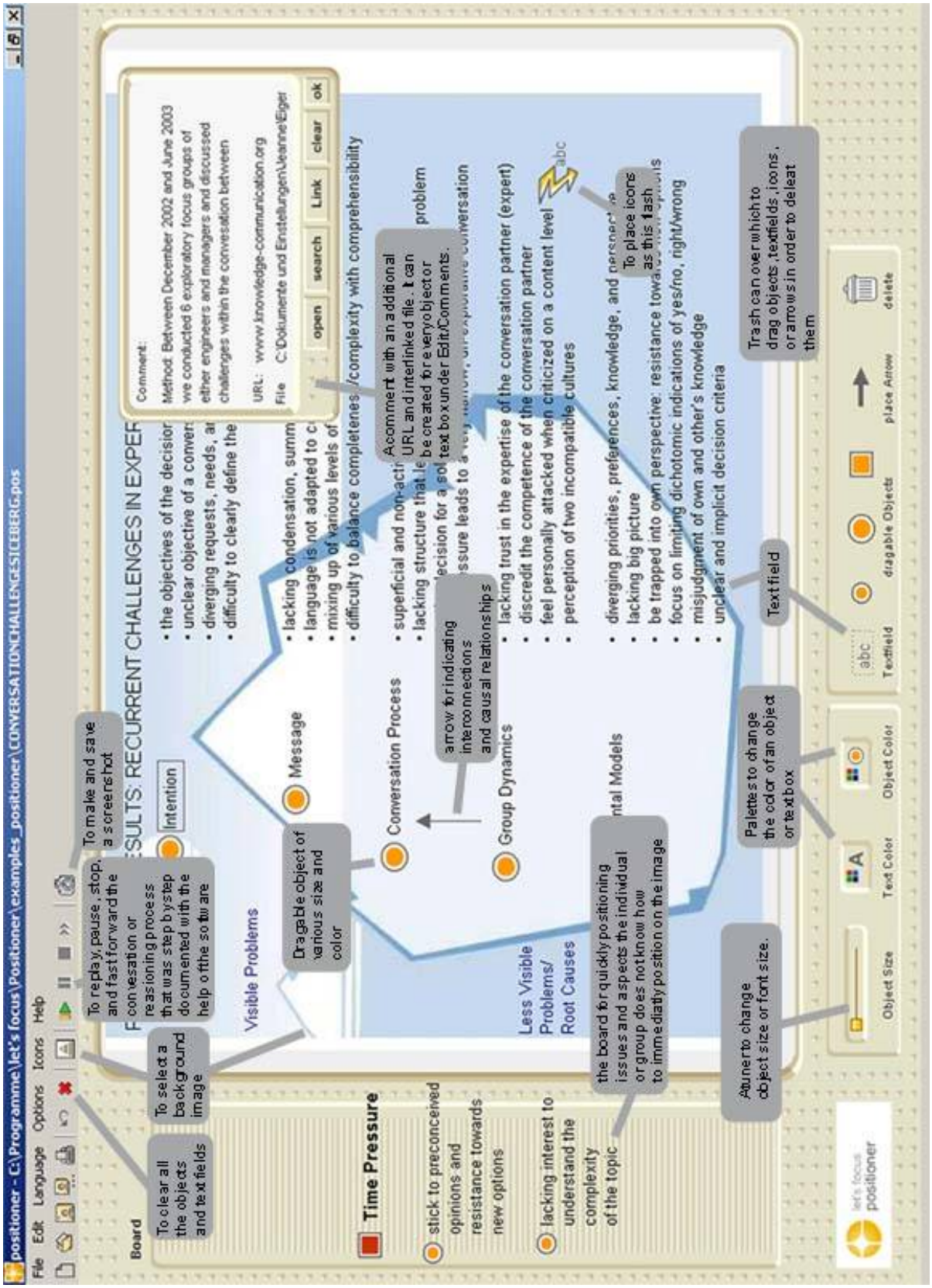
The *let’s focus Ruler* supports tasks, in which teams or individuals have to undertake and compare evaluations along several dimensions (e.g. client- or competitor evaluations). The ruler makes it possible to discuss and take into consideration over forty decision variables concurrently. In this stance, the tool can also be used to develop scenarios or strategies. (let's-focus, 2006).

The *let’s focus Tracker* supports the planning, moderation, and real-time documentation of workshops or meetings. Through the tool, participants can visualize the meeting goals and the agenda steps that are needed to achieve them. Main contributions of the meeting or workshop can be positioned along the track. The main idea behind the let’s focus Tracker is to graphically depict the course of the current meeting. In this way, meetings can be better structured and it can be easily uncovered if a conversation digresses into side tracks. At the end of a meeting, the completed track can serve as synthetic minutes. Contrary to the other tools of the let’s focus suite, the let’s focus Tracker is not bound to a specific task, but can be an instrument to structure the communication process of all sorts of meetings (let's-focus, 2006).

The particularity of the *let’s focus Positioner* is a large library of interactive and in part animated templates of diagrams and visual metaphors that a user can load as a background and use as a loose or more strict structuring device on which to position his/her content. As the Positioner is the tool with which we conducted the experiment,

*Appendix **5*** shows all the functionalities of the tool.

Appendix *5*: Functionalities of the let's focus Positioner 2.1



In the following, we describe the functionalities of let's focus Positioner and discuss briefly their intention and supposed use.

Select a Background

A distinguishing feature of let's focus Positioner is that its user (e.g. the moderator of a meeting) can choose between a variety of backgrounds. These are either diagrams (i.e. Ishikawa, Balanced Scorecard, Five Forces, Expert Web, Value Chain, or Ansoff Matrix) or visual metaphors (i.e. a radar, an iceberg, a bridge, geographical maps, a ladder, a pyramid, a wheel, or a funnel), some of which are discretely animated. Users can also load personal backgrounds (e.g. photographs). Users are free to choose whether they would like to use just one image or diagram for the whole conversation or whether they would like to work with two or three visuals that support specific phases of the conversation process. The suggestion is that a trained facilitator would realize when a group is stuck in a certain approach and could propose a different image

The idea is that the individual or group selects a visual guideline or cognitive and communicative frame with which to approach and structure an issue or conversation. The frame is cognitive in so far as it shapes the way people view and structure a problem or task. These diagrams and metaphors comprehend also a communicative aspect since they provide a common ground and language to all the participants of a conversation. By providing content-specific visualizations and structuring methods (as opposed to content-unspecific visualization like a simple mapping technique) (Fischer *et al.*, 2002), the tool facilitates collaborative processes and outcomes.

Select a (Pre-configured) Template

let's focus Positioner provides a set of prefabricated templates to structure a meeting that aims, for example, at a stakeholder analysis, or at the evaluation of an merger. The templates combine a background image (diagram, visual metaphor) with some default text-fields and objects. The idea is similar to the one of the background functionality. In this case, however, the provided structure is more tightly guiding.

Place Objects

Users can drag and drop objects that have the form of a circle or of a square with a textbox next to them. Each (important) contribution and thought can be documented as an object. The color and size of both object and text can be changed.

Place Text Fields

Users can place textboxes that have no adjacent object to them. Visually, they can be used for aspects, which do not represent a major "point" or statement in the discussion. For example, they can be used as descriptions for the various parts of the diagrams and metaphors.

Place Arrows

Users can draw arrows that show the interrelationships (causalities, flows, developments, origins, etc.) between various objects.

Place Icons

Users can select from a large array of icons (flash, target, bulb, bomb, green/red traffic lights, etc.) and place them next to textboxes or objects. In this way, they can emphasize a certain aspect and give it a visual indication of the type of information that is displayed (e.g. “idea”, “danger”).

Delete

Users can put objects, text fields, icons, arrows, etc. in the trashcan by dragging the elements over the trashcan. It is not possible to delete the objects by pressing the delete key. The developers believe that, from a communicative perspective, it is important to actually throw an idea away and not simply to make it disappear by the push of the button, as if it had never existed.

Board

The board is the space on the left hand side of the software window. Users have the possibility to deposit an idea or aspect in this area. It can be used as a “parking lot”, on which people can park an aspect and come back later on, in order to first finish the current argument. Also, it can be used to deposit aspects, of which conversers do not know where to put them along the diagram or metaphor.

Comments

The users of the let’s focus Positioner have the possibility to deposit comments. They can use the comments to document why they have positioned a certain aspect or issue at a certain level of the diagram or metaphor, what are the facts behind a specific evaluation, or what are the caveats behind a certain consensus. In that comment field, users can also add a specific URL or a link to a document (e.g. an Excell sheet) for further information or facts.

While the main interface of the Positioner aims to show the major (discussion) points and decisions made on an all-integrating visual, the comments give the groups or individuals the possibility to provide more detailed and background information. The user can show or print all the comments that appear as pop-up boxes and which outline the more detailed information (e.g. facts, reasons why). If the person is interested merely in a summary, he/she can also hide the comments so that only the high level information is visible. The producers believe it to be important to make it possible to “scale” information, i.e. to document and retrieve information at various levels of detail and to easily link the summary view to the more detailed information.

Print

At any stage of the conversation, users can print out the Positioner interface and view intermediate or final results on paper. Producers believe that the print-out functionality comprises various important functions. First, the change in the output media allows for subtle changes in fluidity and flexibility as they are perceived by the conversation partners. While the electronic media suggests that the documentation of the conversation is highly flexible and can be very easily changed, the cold print on paper implies more stability and participants can ‘freeze’ the intermediary results of a conversation and sense a feeling of security and progress. The printed media suggests that official decisions have been taken (Mengis & Eppler, 2005b). Second, with the printouts at hand, conversers can conduct comparisons more easily since screen sizes have tight limits in juxtaposing various Positioner interfaces simultaneously. In the case of a client assessment meeting, for example, conversers can use the Positioner to structure the assessment of each client. The print-out function makes it then possible to compare

the various client assessments. Finally, the media change from the electronic to the physical media is also important to include haptic and tactile senses that foster innovation and knowledge creation (Hatwell *et al.*, 2003).

Save

Users can save the Positioner document.

Make a Screenshot

Users can make a screenshot of (preliminary) results or of the current state of their discussion/thinking. The function of the Screenshot is necessary to include the let's focus Positioner document in textfiles, presentations, etc. In addition, similar to the print-out function, it serves to "freeze" a (preliminary) result of a conversation and to create a sense of stability and accountability.

Compare two Screenshots

Users have the possibility to make comparisons with a previously made screenshot. They can, for example, use one template to assess a past situation, make a screenshot, then make an assessment of the current situation, and then load the previously made screenshot. The screenshot will appear semi-transparently so that the image of the assessment of the present is overlapping the one of the past. In this way, comparisons between two time periods or between two clients, objects, etc. are possible.

Change Size of Objects and Fonts

With the size ruler, users can change the size of objects, icons, and fonts.

Change Color of Objects and Fonts

With the color palette, users can change the color of text fields, objects, and arrows.

Clear

Users can clear all objects, text fields, icons, arrows, etc., which are placed on the Positioner so that only the initial background image remains.

Sign

Users can document the author and the day of the file and give a brief description of its content.

Undo

Users can undo any action they have done (placing objects, selecting backgrounds, etc.).

Languages

User can switch between a German, English, Italian, and a French version of the software.

Replay Function / Pause / Fast Forward / Stop

The replay function permits users to review the process, through which the final image, e.g. the result of a discussion, has been created. One can envision the whole process (from the initial template/background to the

final image) through which the group went through. Objects and textboxes will pop-up one after the other. The idea behind this functionality is that often, people forget or have never known (since they have not been present) how or why a certain conclusion or agreement has come about. This feature permits persistence i.e. traceability (Bregman & Haythornthwaite, 2001) in the process of the conversation. One can see, for example, that a certain concept was renamed or first positioned at another level of the diagram. As in a video or audio recorder, the replay of the development process of a Positioner image can be paused or stopped and users have the possibility to do a fast forward.

Delete Replay Function

The recording of the process through which the image got developed can be deleted. This functionality is interesting for example when one creates a template and isn't interested in the process that lead to the creation of the template, but rather on the processes of the following interactions.

Import

Users can import Excell-sheets or another positioner document.

Export

The software provides the functionality to export a Positioner document as excell-file (to further use the text within the various categories) or as .jpg picture.

Help

let's focus Positioner has a small help function, which includes also a guided tour and that explains how to use the software.

Appendix 6: Distribution of Items - Tests of Normality

Factor	Item	Mean	Standard Deviation	Skewness (St.Error)	Kurtosis (St.Error)	Kolmogorov-Smirnov (sig.)	Shapiro-Wilk (sig.)
EP	1.	.6875	.73193	1.822 (.299)	6.470 (.590)	.288 (.000)	.678 (.000)
	2.	2.3214	.86297	-.330 (.441)	-.939 (.858)	.284 (.000)	.831 (.000)
	3.	.7656	.92139	1.245 (.299)	.895 (.590)	.266 (.000)	.744 (.000)
BP	1.	1.2813	.89918	1.433 (.299)	2.510 (.590)	.373 (.000)	.748 (.000)
	2.	1.6094	1.09279	.464 (.299)	-.352 (.590)	.272 (.000)	.899 (.000)
	3.	1.5000	.85449	.394 (.299)	-.561 (.590)	.299 (.000)	.841 (.000)
	4.	1.2295	.58860	.418 (.306)	.637 (.604)	.373 (.000)	.751 (.000)
	5.	.8594	.75313	.700 (.299)	.488 (.590)	.341 (.000)	.698 (.000)
	6.	.8906	.66945	1.439 (.299)	6.456 (.590)	.270 (.000)	.809 (.000)
CG	1.	.9531	.57541	.511 (.299)	2.241 (.590)	.361 (.000)	.714 (.000)
	2.	.9531	.69988	.638 (.299)	1.006 (.590)	.317 (.000)	.791 (.000)
CC	1.	1.4688	.61641	.122 (.299)	-.236 (.590)	.308 (.000)	.780 (.000)
	2.	1.3750	.70147	-.392 (.299)	-.484 (.590)	.282 (.000)	.807 (.000)
	3.	1.3906	.76878	.272 (.299)	-.168 (.590)	.288 (.000)	.847 (.000)
RC	1.	.3015	.63842	5.488 (.302)	2.331 (.595)	.459 (.000)	.536 (.000)
	2.	.4688	.90797	2.197 (.299)	4.513 (.595)	.416 (.000)	.584(.000)
	3.	.3750	.65465	1.883 (.299)	3.656 (.595)	.420 (.000)	.616 (.000)
DC	1.	.9219	.62500	.456 (.299)	1.225 (.595)	.331 (.000)	.762 (.000)
SGP	1.	.7969	.73850	1.565 (.299)	5.283 (.595)	.314 (.000)	.714 (.000)
	2.	.8906	.73716	1.404 (.299)	4.630 (.595)	.332 (.000)	.734 (.000)

Notes: The tests of *normality of distribution illustrate that* several variables show considerable skewness and/or kurtosis. In most cases, many of the skewness values are even more than twice the value of the standard error. By a frequent standard error of 0.299 of the skewness, the skewness itself ranges from 0.122 ("How many disagreements regarding different ideas were there during the one hour discussion?") up to 5.49 ("How much anger was there among the members of the group?"). In the non-tool condition, skewness is even more positive. In addition, some of the variables have quite kurtose distributions (which ranges from -0.037 for "I shared with my group members all the relevant insights, information, experiences that I deemed relevant for the task" to 6.456 for "At every point in time I knew why the group was discussing a specific issue."). Kolmogorov-Smirnov and Shapiro-Wilk tests of normality confirm the fact that variables show a non-normal distribution. Unfortunately, treating the variables with a logarithm did not improve the situation significantly. As a general tendency, respondents reported quite positively (or uncritically) on their or the groups behaviour. One possible explanation for the non-normality of our distributions is our small sample size (Yourstone & Zimmer, 1992). An additional explanation for the non-normality could also be that students were only poorly motivated to reflect critically on the questions of the questionnaire after having participated in the relatively long experiment of one hour. Furthermore, biases of social desirability (Edwards, 1990) or of acquiescence (Hurd, 1999; Paulhaus, 1991) might also be reasons for the non-normal distributions we found. The subjective impressions of the researchers, who attended the experiments as observers and who organized the correct filling out of the questionnaires, found that for constructs, that are quite easily observable like equal participations, the turn taking was not as balanced as respondents reported and that there was a difference between the respondents' exposed theories (written or oral self-descriptions of one's/an organization's behaviour, values, beliefs) and the ones in use (those more implicit values, beliefs, and assumptions manifested in personal/organizational practice) (Argyris & Schön, 1978).

Appendix 7: Original Scales with Factor Loadings and Cronbach Alphas Prior to Scale Adjustments

Factor	Item	Factor Loading	Eigen-value	% of vari-ance ex-plained	Chron-bach alpha
Equal Participa-tion (EP)	1 There were not one or two people who dominated the discussion	0.874	1.77	0.59	0.65
	2. There was an adequate participation from all members of the group.	0.814			
	3. The other members of my group paid attention to the comments I made.	0.586			
Big Picture (BP)	1. The conversation process was very clear	0.806	2.90	0.48	0.78
	2. We never lost time on discussing irrele-vant issues	0.724			
	3. We never lost time on too detailed discus-sions	0.602			
	4. I always knew how a specific contribution related to the more general topic of the discussion.	0.603			
	5. At every point in time I knew why the group was discussing a specific issue.	0.774			
	6. I knew at every point in time where we where in the discussion	0.632			
Common Ground (CG)	1. During the discussion the group created a shared and deep understanding of the topic.	0.829	1.66	0.55	0.55
	2. During the conversation, the group devel-oped and shared a common language to deal with the task	0.854			
	3. I could now better adjust my communica-tion style to the other members of the group.	0.492			
Task Conflict (TC)	1. How many disagreements regarding different ideas were there during the one hour discussion?	0.838	1.96	0.65	0.73
	2. How many differences about the content of decisions did the group have to work through?	0.749			
	3. How many differences of opinion were there within the group?	0.837			
Relationship Conflict (RC)	1. How much anger was there among the members of the group?	0.854	2.35	0.78	0.85
	2. How much tension was there in the group during the exercise?	0.898			
	3. How much personal friction was there in the group during decisions?	0.901			
Decision Com-mitment (DC)	1. I feel confident that our group made the right decisions	0.709	1.669	41.7	0.48
	2. The group was better at making the deci-sion than I could have done by myself.	0.674			
	3. The decisions were unanimous (that is, all four of us agreed) before the two managers of my group took a decision.	0.424			
	4. There was a lot of agreement in the group.	0.730			
Satisfaction with Group Performance (SGP)	1. I am satisfied with my group's set of solu-tions	0.881	1.74	0.58	0.63
	2. I am satisfied with my group's perform-ance	0.735			
	3. I am satisfied with my performance on this assignment.	0.650			

Notes: Items reported in grey are the ones we had to drop

Appendix 8: Group Comparison of Means between Tool- and Non-Tool-Condition

Construct	Non-Tool Condition Mean (S.D.)	Tool Condition Mean (S.D)	d	t^2	p
Equal Participation	0.89 (0.73)	1.19 (0.94)	-.30	-1.41	.165 n.s.
Big Picture	0.99 (0.30)	1.46 (0.67)	-.47	-3.53	.001**
Common Ground	0.84 (0.50)	1.06 (0.61)	-.22	-1.58	.120 n.s.
Task Conflict	2.55 (0.57)	2.63 (0.57)	-.07	-.52	.608 n.s.
Relationship Conflict	3.52 (0.76)	3.71 (0.53)	-.19	-1.16	.250 n.s.
Decision Commit-ment	0.90 (0.64)	0.94 (0.62)	-.03	-.20	.843 n.s.

Table 4: ***Group Comparison of Means between Tool- and Non-Tool-Condition***

Notes: SD = standard deviation, d = effect size, t^2 = t-test, p = p-value

**** Significance at .01 level, * Significance at .05 level**

The means comparison between the tool and non-tool condition shows significant means differences only with regard to the "big picture" construct. The mean is significantly higher in the tool condition (mean: 1.46 (S.D.: 0.67) than in the unsupported condition (mean: 0.99 (S.D.: 0.30). The individuals in the non-tool groups struggled less to gain the big picture and they were more satisfied with their performance than the individuals interacting with the facilitation of the tool. Although we have not expected that the tool has a significant positive impact on the level of the means, the significant negative effect for the big picture construct can be explained by a low familiarity with the tool and the use of an inexperienced moderator (person using the tool). Both aspects led to breaks in the communication flow, an exaggerate time allocation for the documentation of details, and an unbalanced participation (see discussion of open-ended qualitative questions, Table 2*).*

Appendix 9: Pearson's Inter-Construct Correlations Controlling for the Tool/Non-Tool Condition

	EP no-tool/tool	BP no-tool/tool	CG no-tool/tool	TC no-tool/tool	RC no-tool/tool	DC no-tool/tool
Equal Participation (EP)						
Big Picture (BP)	.37*/.49**					
Common Ground (CG)	.18/.35*	.20/.54**				
Task Conflict (TC)	-.57**/-.24	-.31/-.10	-.10/.24			
Relationship Conflict (RC)	-.55**/-.33	-.50**/-.47**	-.18/-.60**	.50**/.05		
Decision Commitment (DC)	.28/.27	.37*/.52**	-.10/.31	-.51**/-.22	-.35/-.26	

Notes: ** Significance at .01 level, * Significance at .05 level

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