Knowledge construction and risk induction within a large high-tech firm

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Abstract
An ethnographic case study of two interacting workgroups within a large North American aerospace company allowed us to propose a dialogical model describing both verbal and non-verbal interactions between group members leading towards knowledge complexification on the one hand and risk mitigation on the other hand. Factors leading towards dialogical breakdown and subsequent risk induction are also presented. This study attempts to bridge the areas of knowledge creation and risk induction at the interpersonal/workgroup level.

1. Introduction
R&D organizations are often pre-occupied with the notion of risk in terms of its assessment, characterization, and management of [1, 2]. Such organizations are also fertile grounds for the knowledge they possess as well as create. Yet there is very little in-depth literature as to the possible inter-relationship between knowledge and risk. There have, however, been numerous ‘passing’ comments such as Kloman [3] who contends that risk cannot be avoided since “every decision, no matter how carefully conceived or studied by the experts, creates consequences that are impossible to anticipate” and that we must “recognize the limits of our knowledge”. Others such as Weick [4] seem to imply that risk mitigation can be attained across the construction of a more complexified knowledge when we hear such words as “simplifications produce blind spots...” and “...with more differentiation comes a richer and more varied picture of potential consequences”.

Our own simplistic starting point begins with the individual within the workgroup environment on the basis that: a) organizational knowledge creation and organizational sense-making begins with the individual [5, 6]; and b) the workgroup is a constitutive and fundamental entity within the organization for understanding social phenomena [7]. This paper thus, across an ethnographic case study of two workgroups within the R&D organization of a large North American aerospace company, attempts to propose a dialogical model describing both verbal and non-verbal interactions between group members leading towards knowledge complexification on the one hand, and risk mitigation on the other hand.

Towards this objective, we first present our epistemological position on knowledge followed by a general definition of risk. We then propose an initial conceptual framework, followed by our empirical results and a final conceptual model.

2. Knowledge as synthesis of emerging antithetical concepts
Knowledge is seen as occupying a central place in contemporary modern societies. Yet numerous equivocal concepts have resulted in a range of definitions. The following brief review on the ‘knowledge of knowledge’ is only meant to illustrate how it is a continuously emerging field, often in the form of emerging antithetical (yet complementary) concepts. For example, certain authors have come to see it as being divisible into two broad antithetical categories: namely, representational and anti-representational knowledge [8, 9]. The representational view sees knowledge as being a representation of a pre-given world with these representations resulting from human cognition [8], where cognition in this case consists of purely ‘rational’/logical dimensions. Such knowledge, being universal and codifiable, is seen as being storable and easily transferable in a controlled manner between individuals and organizations in formal and systematic manners [10].

The anti-representational view sees knowledge as interpretation, as relationship and as process [8]: 1) Knowledge as interpretation emphasizes the tacit and personal subjective aspects of knowledge that is hard to formalize and hard to communicate, share or transfer [11]; 2) Knowledge as relationships emphasizes that knowledge is intrinsically relational to its surrounding world – knowledge is a result of human mental acts, be it individual, group or social, and those acts are interdependent on various socio-cultural contexts; and 3) Knowledge as process emphasizes the dynamic and
fluid aspects of knowledge, emerging from the interaction between subjectivity (e.g. beliefs, emotions, etc.) and objectivity (‘truth’) [11] – furthermore, knowledge is seen as a non-static entity resulting from the process of ‘knowing’ by which human beings make sense of the world.

The knowledge taxonomy of non-representational vs representational can itself be transposed into an alternative binary or antithetical taxonomy of tacit vs explicit knowledge [5]. Explicit knowledge covers all of the representational view of knowledge, but can also overlap onto anti-representational dimensions such as interpretable ethnographic texts [12], text as discourse and fiction [13], or more fundamentally, includes the very nature of the interpretative/contextual semantic aspect of language [14]. Tacit knowledge on the other hand is solely non-representational in nature, including: “informal and hard-to-pin-down skills and crafts”; “subjective and personal insights, intuitions, hunches and inspirations derived from bodily experience”; and “beliefs, perceptions, ideals, values, emotions and mental models so ingrained in us that we take them for granted...yet shapes the way we perceive the world around us” [15, p. 319].

Furthermore, additional binary or antithetical knowledge distinctions related to the explicit/tacit dyad include know-what and know-how, declarative and procedural, practical and theoretical, etc. [16]; not to mention antithetical distinctions that can be more easily related back to the representational vs non-representational classification such as process and object; or other stand-alone binary distinctions such as knowledge creation and knowledge application [16].

Nissen [16, p. 233] attempts to integrate this “plethora of diverse, often-divergent concepts and perspectives” within a framework of four dimensions: explicitness, reach, life cycle, and flow times. These dimensions or variables can in themselves, when looking at them in terms of degrees (whether in a discrete or continuous sense) be looked upon as encompassing the dyadic extremes of tacit vs explicit, individual vs organization, knowledge creation vs knowledge application, and fast vs slow rates of flow.

Our own position is not to add another set of categories or classifications, but rather to appreciate the antithetical or dyadic patterns which already exist and to view them in the sense of Latour [17]: who warns us against viewing reality as purified categories, but rather as categories which continuously interpenetrate and hybridize one another. For example, tacit knowledge, for the sake of representation, is typically shown as being fully distinct from explicit knowledge, yet in reality both interpenetrate one another and contain different degrees of each other along a continuum [18, p. 636]. It is in this sense that we view our ‘knowledge of knowledge’ as being a continuously emerging field integrating various contrapositions (e.g. representational vs anti-representational knowledge, tacit vs explicit knowledge, practical vs theoretical, etc.), whereby their hybridization occurs across iterations of synthesis where “knowledge is created in the spiral that goes through pairs of seemingly antithetical concepts such as order and chaos, micro and macro, part and whole…tacit and explicit, self and other, deduction and induction...” [19, p. 14]. In essence, knowledge and its creation have an infinite range of ambiguous1 or antithetical concepts to tap from as knowledge expands ontologically from the individual to Society [20]. Hence, in our view, knowledge consists of the synthesis of constantly emerging antithetical concepts – thus echoing Maturana and Varella’s [21] as well as Kakihara and Sørensen’s [8] view of human knowledge being a result of emergent processes of knowing.

3. Risk induced by not integrating antithetical concepts

The basic definition of risk adhered to in this paper is that risk represents the potential for an undesirable consequence [22]. Furthermore, risk categories (e.g. quality, financial, organizational, health and safety, etc.) are more often than not inter-related [23, 24, 25].

Beck [26] describes risk as being generated by a ‘second order effect’ consisting of industrial society’s way in which “hazards and insecurities induced and introduced by modernization itself” are dealt with; and implicitly argues that the refusal to recognize and integrate various underlying complementary antithetical concepts or ambiguities has manifested itself into various forms of risk. For example, one of the risks Beck [26, p. 70-71] identifies is in relation to the antithetical dyad consisting of the collective vs the individual. Here, Beck argues that the present lopsidedness towards the individual has resulted in the sole pursuit of private interests on the part of large corporations which has produced risks that menace life on earth, thereby menacing the very interests which private corporations seek in the first place. Other similar dyadic imbalances have essentially induced other risks in which: 1) an instrumental reasoning of the type ‘what isn’t measurable does not exist’ now predominates, hence evacuating the more subjective and intuitive forms of knowledge – thus leading to an

1 Here, we adhere to Weick’s [4] definition of ambiguity as being actions, ideas or concepts that are contradictory or “capable of being understood in two or more possible senses...”
inability to recognize invisible risk due to an obsession to always have explicit 'evidence' before contemplating further action [26, p. 49 and 53 and p. 81-83]; and 2) the refusal to recognize the presence of hybrid categories and conceptions (themselves caused by interacting antithetical concepts) lead to risks caused by oversimplifications of an inherently inter-related and complex world [26, p. 50-55]. Beck’s thesis is also in line with Weick’s [4, p. 60 and 167] argument that with “diverse views”, “ambivalence” and “…more differentiation comes a richer and more varied picture of potential consequences”; and that constancy of ambivalence ensures required organizational flexibility and resilience, since it generates necessary re-adjustments to preceding actions, which if left unchecked can lead to significant consequences [4].

4. An initial framework

The two preceding sections lead us towards an initial framework whereby even though risk and unintended consequences remain unavoidable, one can reduce it by attempting to factor in as many different sources of antithetical or equivocal points of views (or ambiguities) as possible. The resultant knowledge would also be expected to be more complexified. Figures 1A and 1B show the two extremes whereby in one situation agents have initially incorporated and integrated a high degree of antithetical concepts in their cognitive process vs the other situation whereby little or no ambiguity is recognized.

**Figure 1**: A) Relatively complex knowledge and less risk generated as a result of integrating ambiguity. B) Relatively simple knowledge and higher risk as result of integrating little or no ambiguity.

4.1 The individual and workgroup setting

Our own ontological starting point as to where ambiguity, contradiction or equivocal points of views are first integrated is at the level of the individual [5, 6]. Furthermore, we are also interested in examining the individual within the context of a workgroup environment. According to Enriquez [7, p. 97 and 101], “the group constitutes the privileged location for the comprehension of collective phenomena”, in which the “group only establishes itself around an action to accomplish, a project to work on or a task to complete”. Group members interact with one another whereby communication is often viewed as the central process of the group. Keeping in mind that communication across dialogue is a prime mechanism for the sharing, conversion and creation of organizational knowledge [5, 19, 20], it is therefore at the level of the workgroup that we first ask ourselves how and to what degree ambiguity is integrated.

5. Research Aim and Methodology

This research sought to determine how knowledge is constructed and risk is induced within a large North American high-tech firm. Towards this end, our intent was to study interactions within and across one or more work groups within a given firm.

5.1 Field site

The research site, given the pseudonym, NorAm Aircraft Engines, is an aircraft engine manufacturer which employs over 4000 people world-wide. Preliminary discussions with a first workgroup (the Engine Operability Development or EOD group) not only confirmed their interest to participate, but were involved in bi-weekly meetings with another group that had not been initially identified (the Engine Component Rig Testing or ECRT group). This second group was also approached and accepted to participate.

5.2 The EOD and ECRT workgroups

The EOD group is responsible for ensuring the development of adequate engine operability *envelopes* throughout all phases of engine development programs. The proper establishment of the engine operability envelope is of critical importance, in that it delimits the boundaries beyond which the aircraft risks running into critical compressor surges or other types of catastrophic engine failures. EOD group members have a good general understanding of the various engineering disciplines involved in engine design and development. A principal objective of the EOD group is to ensure meaningful engine component test data is generated. Establishing the type of engine test data to be generated is negotiated between the EOD group, the various engineering specialty groups, and the ECRT group; the latter being responsible for the generating
and integrity of the required engine component test data. In turn, the ECTR group’s responsibilities include the development and preparation of component test rigs (required for each new engine development program), their subsequent test runs, and the proper collection of the test data. Both groups interact with each other daily (informal) and also meet bi-weekly.

5.3 Data collection

A qualitative ethnographic case study approach was adopted using direct non-participatory observations and interviews. This was conducted over a three month period in early 2007. Interviews were either semi-structured or ad hoc in nature. Our aim was not just to test or validate the proposed framework described in the previous section 2.3, but to abandon and re-build where necessary. Within this perspective, it was especially important to be vigilant for ‘emergent’ categories, and hence borrowed from Schwartzman’s [27, p.47-72] ethnographic studies in organizations involving a dialogical inductive-deductive process between empirical evidence and theoretical elaboration across thick descriptive writing.

Three embedded units of analysis within the single case study were chosen, namely: 1) the bi-weekly inter-group meetings between EOD and ECRT; 2) the EOD group; 3) the ECRT group. For this paper, we limited ourselves mostly to the first unit of analysis.

The primary research design criterion sought was trustworthiness [28], involving the constructivist sub-criteria of: i) credibility via both the saturation of findings and triangulation of data collection to obtain complementary perspectives (as opposed to triangulation in the positivistic sense of ‘intersection’ of findings) of what people say vs what people do [27]; and ii) transferability across thick description. Also in support of this primary criterion of trustworthiness, was our desire to attain reliability of data by ensuring that the research was conducted “as if someone were looking over our shoulder” [29, p. 38]; that is, making sure we had rigorous documentation of data (from observations and interviews) so as to provide an adequate audit trail. For observations, we drew upon Spradley [30, p. 63-84] who recommends the use of short in vivo condensed notes, which were often complemented with on-site in vivo digital recordings; 2) to be subsequently elaborated within 24 hours or as soon as possible in a separate journal of ‘expanded notes’; 3) along with a reflexive journal on personal emotions and reactions in regards to recorded experiences; and 4) analytical notes that consisted of interpretations on what was observed, as well as questions or further points that needed to be verified.

5.4 Data analysis and main research steps

Descriptive data from observations and interviews were manually analyzed and interpreted in a separate journal as per Spradley [30] against a priori concepts as well as for emerging categories which came about through repeated identification of comments and actions. The nature of the data that was collected (digital recordings and hand-written observations) allowed us to analyze for verbal and non-verbal (voice tonality, facial expressions, body language, etc.) cues thus bringing forth important contextual information.

Unexpected emergent dimensions were essentially triggered by the researcher’s generalist formation in both human sciences and epistemology. These dimensions were initially based on intuitions, which upon repeated observations, either confirmed themselves as emergent categories (for example, the use of narratives, story-telling, perspective-giving and perspective-taking), or upon further parallel reading, became the basis for new theory building. As such, it is perhaps useful to present a summary of the main research steps involved in this study within a format finding its inspiration from Schwartzman [27]:

- Entry into the field and specific units of analysis made available a priori – this involves a certain degree of immersion and discovery of the field across observations and first contacts with the participants
- Gradual familiarisation with certain specialised terms used in each of the specific units of analysis studied; description of observations become more methodical in regards to the activities and comments of the participants, context and the researcher’s own intuitions on potential ‘categories’
- A first analysis: certain phenomena (whether known or novel), as a result of repeat occurrences, are retained; further readings ensue as a function of the familiarity, or lack of, in regards to the phenomena repeatedly observed
- A second analysis: under what conditions do the phenomena repeat themselves? What are their implications?
- Progressive building of framework: this involves a mix of revalidating certain a priori concepts, the abandonment of others, and the addition and re-integration of new categories into a new or modified design or layout
- Progressive redundancy of observations indicate saturation
• Whenever possible, validation and ‘testing’ of the new framework by retroaction across all three units of analysis studied.

6. Results, analysis and interpretations: The bi-weekly inter-group meetings

My first and lasting impression upon assisting the bi-weekly inter-group meetings between EOD and ECRT was of a high degree of camaraderie within each group as well as between both groups; extending itself between the two group managers (Gerry and Frank).

The meetings themselves lasted anywhere between 40 to 60 minutes. With time, we were able to confirm within each meeting the existence of three chronological periods which seemed to naturally flow from one to the other; namely, the pre-agenda, the ‘formal’ agenda and the post-agenda meeting periods.

The pre-agenda period consisted of the initial 5-10 minutes of each meeting. During this period members would either joke and cajole one another; informally discuss technical issues that were not necessarily part of the formal agenda; or simply converse on various social topics (little league hockey, house renovations, car problems, etc.). On other occasions, members discussed specific technical issues related to joint project activities. This was often accompanied by the act of sketching a particular view of a rig or engine component that one member was trying to describe, justify or clarify. Throughout such conversations sketches were often drawn and modified in successive superimposing steps by each of the interacting members before finally converging towards a mutually agreed ‘version’. During this process, active sense-making was observed, whereby various cues indicating understanding, questioning or disagreement were easily discerned across words such as “Yep”, “Oh really? I thought the chamfer had a smoother profile than that...” and “No, the airfoil cooling hole needs to be drilled at 45 degrees...”. Similar types of sense-making also occurred with the use of pre-existing 2D drawing cross-sections. Here, existing blue-prints were typically modified (via successive iterations between interacting members) with pen/pencil to explain one’s existing perspective (perspective-giving), understand someone else’s perspective (perspective-taking) or construct new perspectives (perspective-making).

The ‘formal’ agenda period was always initiated by Gerry’s (the EOD manager) calling out the first agenda item on the agenda sheet. The agenda sheet consisted of a series of one or two-line descriptions identifying the development engine model/test rig combination in question, the principle tasks being monitored, a completion target date for each of these tasks, and the current status of the task in question. Most members had a copy of the status sheet, while those who had forgotten it were familiar with the tasks they needed to report on (while occasionally looking at their neighbor’s copy). Gerry’s kick-off words such as “QA510/Gas Generator?” would prompt a response by one of the attending members. Such responses, rather than simply ‘closing’ the agenda item often triggered comments, inputs or questions from other members. The following example shows how such an item called out by Gerry triggers an initial status description, which is then followed by subsequent discursive dialogue amongst the various meeting members:

Gerry: “Ok. QA 720/inlet distortion test?”
Jon: “The plenum is now at the Manufacturing Development Shop and they should be able to have a look at it by this Friday – they said they'll be able to install new pads for the two new additional ‘rakes’; and they'll be able to respect the distances...It's just that with those walls the spaces aren't the same anymore...we get a larger gap (uses hand/arm movement to represent the distance)
Lloyd: “Yep. One is like this and the other is like that (uses hand and arm movement to show two different space distances)”
Jon: “Ya, that’s it...I managed to get some measurements on the shrouds this morning, so now we’ll be able to re-assemble everything. When they disassembled the shroud section they saw that the capacity probe filters were broken; but we don’t think we’ll need them for the upcoming tests...”
Ian (who is not involved in the project): “That’s what they figure we don’t need anymore”.
Jon: “And they didn’t need to bolt anything down...”
Frank: “So that means it’s been passing by the holes”

Despite the ‘formal’ agenda listing and monitoring of various items of activities related to various rig testing projects, discussions were more often than not discursive/digressive in nature and involved a good dose of humor and socialization.

And finally, the subsequent post-agenda period of discussions seemed like an organic or blurry extension to this ‘formal’ period, typically involving a discursive continuation of the final agenda topic. These periods varied anywhere between 5-10 minutes within the meeting room, but could go as much as 20 minutes or more as people often decided to ‘airlift’ the meeting towards the nearby ECRT workgroup area.

6.1 Categories

Various categories and patterns were discerned within the inter-group meeting context. The following subsections discuss the five main categories identified.
6.1.1 Narratives. Very often, perspectives that were transmitted between members across all three periods of the morning inter-group meetings, were done so in the form of narrations. Here, we define the narrative form as being concerned with the temporal ordering of events, ideas and actions with a focus on “their sequential patterning, their duration and pace, their context and the role of actors” [31, p. 965]. Moreover, narratives were discerned across all of the inter-group meetings which had been digitally recorded (10 meetings). Narrations were used as part of overall descriptive explanations given by various members to either assure others that actions had been taken, justify one’s own position, report on progress in relation to a specific activity, provide background information to the meeting audience in general or simply to present old knowledge in an entertaining fashion.

The following is an example of story-telling by Ian as he describes the status of an activity:

Ian: “Helen came to see me yesterday and mentioned ‘This’ll be way too complicated to try and make an evaluation, and so on’...And then the union got involved by saying ‘No. The noise level is way too high. It’s out of the question people work under these conditions.’ I was a bit pissed-off in that ‘Hey! What’s the big deal? Everyone’s using earmuff’s no?...’”

The numerous examples of narratives bring up the notion of a more general category of perspective-giving. Boland and Tenkasi [32, p. 357] speak of narratives as being inherent to the process they refer to as “perspective-making”; but this is in relation to the individual actually generating the narrative. Yet, as Dickey et al [33, p. 50] recently remind us in their own literature review, perspective-making, when articulated towards another individual, involves “the objective...to induce a perspective” towards this very individual known as “perspective giving or perspective setting”.

6.1.2 Perspective-giving. All of the examples of narration or story-telling can be included within the more general category of perspective-giving. But many more examples of non-narrative forms of perspective-giving were observed; and constituted a major form of exchange in perspectives between the meeting members throughout all of the meetings that were attended. Here we define the non-narrative form as “being concerned with non-temporal patterns such as relationships between propositions, argumentation, descriptions, ideas and evaluations” [31, p. 965].

One example of non-narrative perspective-giving shows Gerry giving a pedagogical-like explanation to Frank and the rest of the members as to why the company takes four repeated test measurements:

Gerry: “The reason why we take four measurements is because if ever there’s a problem you’ll see it right away...”
Frank (interjects in agreement): “Oh, ok ya...”
Lloyd (agrees): “Yep.”

6.1.3 Perspective-taking. All examples of perspective-taking would have us ask whether or not these perspectives were actually being ‘taken in’ by the listening members. When we refer to perspective-taking, we are not speaking of agreement on the part of the listening interlocutor but simply that he has taken the other’s point of view into account before making up or readjusting his own perspective [31, 32].

Sufficient cues were seen and/or heard to indicate that perspective-taking was predominant across all of the inter-group meetings attended.

One example is during a technical discussion between Lloyd and Jon, in which we see Lloyd’s perspective being given, and in turn, Jon taking in this perspective as seen across explicit verbal cues:

Lloyd: “There’s one part missing that’s still at Assembly; it’s just that Daniel Filion wants to have two inspection points taken”
Jon (following Lloyd’s words): “...Ok...”
Lloyd: “The part left on the 170 truck instead of returning back to me...”
Jon (in surprised empathy): “Oh !”

6.1.4 Revision of perspectives. Dialogue between members within the inter-group meeting environment, where perspective-giving and perspective-taking were in constant interaction, led to perspectives being continuously revised; thus echoing Dickey et al’s [33, p. 49] words, that “the ability to change perspective allows individuals to communicate with a multiplicity of partners who hold a wide variety of perspectives”. It often appeared in the form of partial disindications whereby an individual’s assumptions, beliefs or practice could be self-perceived to contain both a degree of pertinence, while also needing to be modified in the face of another’s input. At other times, we could discern an individual’s tentative self-discreditation in the face of the other’s input, reminding us of Weick’s [4] ‘healthy doubt’. On occasion, a ‘full’ or ‘complete’ self-discreditation of an individual’s retained assumption seemed to occur in parallel to the formation of a new perspective as a result of someone else’s input.

Examples of revisions observed throughout the inter-group meetings, were easily discerned across cues such as “Oh ok, now I see what you mean” and “All along I was thinking it was doing...Now I get it.”.

The following example between Ian and Frank in regards to Frank’s proposed idea of conducting a
physical polishing in lieu of a chemical treatment (on Jan’s plexiglass component) shows Jan gradually (and tentatively) revising his own prior belief that doing a physical polishing would take too much time:

Ian: “I’m not sure if we can dip it in acid or something...just to ‘melt’ the surface”
Frank: “But you can polish it physically. It goes pretty fast...”
Ian: “Really?”
Frank (turns to Lloyd): “When you do the polishing it goes pretty fast, no?”
Lloyd (agrees with Frank): “Yep, it’s pretty fast”
Frank: “They start by rubbing it...”
Lloyd: “After the wet scrub”
Ian (in a pondering tone as he parrots Lloyd): “After the wet scrub...”

6.1.5 ‘Dynamic/Static Boundary Objects’ as Boundary Constructions. The different types of mediums used in helping to transmit perspectives within the various intergroup meeting interactions that went beyond verbal articulation included the agenda sheet, active sketching from scratch, sketching to modify existing 2-D drawings and existing 2-D drawings themselves. Some of these ‘objects’ in their static forms such as the existing 2-D drawings could be classified as repositories [34]. And although Bodker [35] acknowledges the activity or mediation that occurs around most of these ‘objects’, they are nevertheless viewed as static representations. Yet in our case, all of the listed ‘objects’ were not only accompanied with some form of visible action on the part of actors, but that it was during the dynamic yet transient modifications of these ‘objects’ by these very same actions that perspectives were both given and taken. In our case study, the agenda sheet was actively modified across Gerry’s handwriting, as the discussions advanced from one item to the next. And in conjunction to this dynamic re-construction of the ‘object’ was the updating of everyone’s perspective of the topic at hand – i.e. we are looking at both imaginary/mental as well as physical de-constructions and re-constructions occurring in tandem.

The active process of sketching and re-sketching was found (across ad hoc interviews) to be a much more meaningful process for the participants as opposed to simply looking at the end-resultant sketch or construct. For example, in portraying gas flows within an engine combustion chamber, if the same explanatory words were used in the absence of specific motions and line drawing movements, one would have a less clear sense of the phenomena being articulated.

In all of these cases, we are looking at physical boundary objects being continually constructed and re-constructed by the subject-actors. Hence, we can speak of boundary constructions (a concept first presented in detail at HICSS-41 [36]) Even 2D drawings without any visible line markings or modifications added to them, were always accompanied by finger movements across various features and physical phenomena the interlocutor wanted to bring a mental attention to (e.g. gas flows, stress distributions, a hole diameter, etc.). This created new mental bracketings [6], necessary for constructing new mental representations within the minds of the various interacting members.

7. Knowledge construction across dialogue

Based on the five categories observed within the inter-group meeting context, we now propose a dialogical model on how knowledge seemed to be constructed. Firstly, our analysis showed the two strong emergent categories of perspective-giving and perspective-taking to be complementary processes allowing interlocutors attain a “shared understandings” [32, 33]. A relatively clear transmission of a perspective not only clarifies a perspective in the sender’s mind (hence perspective-giving = perspective-making [32, 33]), but is also the first step towards providing the potential for the receiver to take in the sender’s perspective. That is not to say perspective-taking is an automatic process as a result of the sender’s perspective-giving. Taking in the other’s point of view, as Mead [37] explained, involves “taking the attitude of the other” and of being fully human by maintaining “an inner conversation with a generalized other”. Furthermore, “communication is unsuccessful when neither party manages to mentally ‘step into the other’s shoes’, to be non-ego-centric” [38, p. 142].

Seen within the inter-group meeting environment was a continuous cycle of immediate reciprocity between the listener-become-speaker and the speaker-become-listener. Perspective-taking was received by perspective giving, or in a more layman’s term, ‘active listening’. This leads us towards a basic ‘perspective coordination’ between two interlocutors named ‘Self’ and ‘Other’ (see central area or ‘loop’ in figure 2).

Closely associated to the perspective giving/perspective taking process was what appeared to be the revision of perspectives in line with Krauss and Fussell [39, p. 2], whereby each member’s perspective within the inter-group meeting was periodically being revised in terms of retained knowledge (as beliefs, opinions, practice, etc.). This revision of retained knowledge occurs as a result of the perspective-making process (reciprocal loop seen on both the left and right hand side of figure 2). In turn, a newly revised perspective retained by a member will
also have an influence on the subsequent incoming perspective being taken in by this same member.

Finally, the centre of figure 2 also shows the incorporation of boundary constructions. Perspective-making/giving by the Self can involve the aid of a boundary construction, which in turn is taken in (perspective-taking) by the Other. On the other hand, it is quite possible that it may not involve the aid of a boundary construction (for example, communication purely via verbal articulation) in which case perspective-making/giving bypasses the boundary construction step and is directly taken in (perspective-taking) by the Other. In turn, the Other changes roles from a perspective-taker to a perspective-maker/giver and once again begins the same process.

Figure 2: Dialogical process between Self and Other incorporating the revision of retained knowledge and boundary constructions.

7.1 Knowledge Complexification as Openness to Antithetical Concepts

As argued throughout section 2, dynamic interaction between complementary oppositions, ambiguities or antithetical concepts is an essential ‘feedstock’ towards knowledge complexification. In this sense, numerous dynamic contradictions were seen at work leading towards the expression and transmission of enriched individual perspectives.

The first and most obvious antithetical dyad at work was the co-existence, interaction and conversion of tacit and explicit knowledge. Explicit knowledge was articulated verbally (as perspective-giving) often in the form of metaphors, analogies and stories, thereby confirming Nonaka et al’s [5, p. 64] externalization (tacit to explicit conversion) at work, whereby individuals use their discursive consciousness towards articulating interactive dialogue. Furthermore, perspective-taking involved the taking in of others’ perspectives which often implied the beginning of learning-by-listening to others’ narratives, whereby members feel the realism and essence of the story that took place so as to convert it into a tacit mental model [20, p. 64]. And finally, when we look closer at the boundary construction aspect of the perspective coordination process, again we can see both explicit codified aspects (existing 2-D drawings, agenda sheet, etc.) as well as more tacit ephemeral aspects, such as hand drawing movements in themselves (which impart a film-like quality); and in this sense transmits a certain degree of tacit knowledge to the perspective-taker.

Other antithetical dyads at work included dialogue vs action as seen across the perspective making complemented by the boundary construction process. In this way, as per Nonaka, Toyama and Konno [19, p. 14 and 16], it provides the basis (in dialectical fashion) for further ambiguities or complementary oppositions to interact together, which in turn, further reinforces the tacit/explicit dyad and its respective conversions.

One interesting antithetical dyad within the intergroup meeting was seen across the complementary strengths of both groups. The Special Test group seemed more centered towards technical and practical hands-on knowledge of the test rig’s capabilities and running. Hence, between the two groups we have a strong combination of practical-technical ‘how to’ and theoretical ‘why’ knowledge which interacted, transformed, entrained and complexified one another.

Another antithetical dyad could be seen across the relative knowledge balance between younger and older members within the meeting room. Often, the older members provided ways in which to solve problems (or avoid them altogether) based on their experience and/or the network of contacts they had amassed over the years. The younger members, on the other hand, tended to be stronger within the realms of information technologies as well as having stronger competencies for numerical modeling activities.

Finally, there was a more basic and primary ambiguity or contradiction at work within the intergroup dynamics which can be directly attributed to the predominance of perspective-taking on the one hand, and perspective-giving on the other: namely the ontological dyad of the individual (as seen across emancipation of self via self-expression (or perspective-giving)) vs the more collective desire of identity towards the other (as seen across genuine listening that attempts to ‘put oneself in another’s shoes’ (or perspective-taking)). Here we can speak of balanced or, as Enriquez [7] terms it, “differentiated” group dynamics. In turn, this allowed for secondary knowledge-rich antithetical dyads described above (e.g. tacit vs explicit knowledge, older vs newer knowledge, practical vs theoretical knowledge) to be actively integrated so as to continuously complexify the knowledge being exchanged.

Figure 3 shows a schematic of the numerous specific secondary knowledge rich ambiguities
specified in previous paragraphs, in a dialectical relationship of mutual reinforcement with the primary ontological ambiguity. The primary ambiguity of ‘emancipation of self’ vs ‘identity towards the other’ allows for specific knowledge-rich secondary ambiguities to be expressed and integrated within the dialogical perspective coordination process (shown in detail in previous figure 2); The expression or integration of these secondary ambiguities also reinforces the primary ontological ambiguity; and in turn, results in an open dialogue results whereby, individuals are open to others’ viewpoints as well as towards revision of their own retained knowledge; all of this resulting in knowledge being continuously complexified and shared.

Adam: “So I’m raising the question: why are we drilling all these holes to simulate the condition?”
Karen: “But if we don’t drill these holes what are the implications?”

Adam seems to ignore Karen’s question, and goes up to the projector screen and adds in a forceful manner while pointing to specific areas of a 2-D cross-section:

Adam: “I’m raising the point because the standing mode at 0.6 might disturb the rate...that’s my point!”

During Adam’s explanation, Karen has been writing down notes without looking up at Adam; while other members have been discussing something else between themselves. It’s as if people are not only hesitant to interact with Adam, but that perspective-taking by others in regards to Adam’s explanations is decreasing. Furthermore, Adam’s attempt at using a boundary construction (pointing at the PowerPoint screen) to help transmit his viewpoint has been unsuccessful, since no one seems to have looked his way – hence, no boundary interaction of perspectives has really occurred. Members gradually adopt a similarly brusque attitude towards Adam’s subsequent questioning. Adam eventually leaves in a huff.

In essence, Adam had shown a strong desire to coerce perspectives onto others, or as Huzzard [40] calls it, “sense-giving”; combined with very little outwards signs of perspective-taking on his part. This gradually entrained a reciprocal loss of desire on the part of others to take in Adam’s perspective. In this sense, both Adam and the meeting members had failed to fully profit from and complexify one another’s views. This, in certain ways, reminds us of Dougherty’s [41] “breakdowns in the perspective taking process due to the actor’s inability to surface and examine their differing interpretive schemes” leading to “unsuccessful cases of new product development”, whereby key players are unable “to reconcile their differences” [32, p. 358]. In this manner, their is a higher probability that potential technical (as well as financial, etc.) risks related to this engine rig testing project lie unaddressed; or worst new risks are created across individual cognitive assumptions that are not properly aired across the dialogical process previously described in figure 2.

The right side of figure 4 shows how a specific individual entering a discussion with the intention of imposing his/her views in a coercive sense-giving manner simultaneously displays an unwillingness to take in others’ perspectives. That person also becomes entrenched in his/her own self-creditation. All this implies an absence of mutual respect with others, while the general ambiguity of ‘emancipation of self’ vs

\[ Figure 3: \text{Expression of the primary ontological and secondary knowledge ambiguities (in dialectical reinforcement) within the dialogue process; leading to knowledge complexification.} \]

\section{8. Risk induction as a result of coercive sense-giving}

Specific events outside of the inter-group meeting gave us glimpses as to how risk can be induced within a workgroup environment. These involved the sudden appearance of a coercive member within a group meeting. The following brief description involving ‘Adam’ (an acknowledged thermodynamics ‘guru’) provides a typical pattern of the dialogical breakdown observed. Adam, who had just joined an on-going design meeting, had immediately started interrupting other meeting members before they had had a chance to fully articulate their questions, ideas and viewpoints. In addition, Adam had adopted an imperious tone as to what should and should not be carried out:

\[ Adam: \text{“I’m raising the point because the standing mode at 0.6 might disturb the rate...that’s my point!”} \]

\[ Karen: \text{“But if we don’t drill these holes what are the implications?”} \]

Adam seems to ignore Karen’s question, and goes up to the projector screen and adds in a forceful manner while pointing to specific areas of a 2-D cross-section:

\[ Adam: \text{“I’m raising the point because the standing mode at 0.6 might disturb the rate...that’s my point!”} \]

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In essence, Adam had shown a strong desire to coerce perspectives onto others, or as Huzzard [40] calls it, “sense-giving”; combined with very little outwards signs of perspective-taking on his part. This gradually entrained a reciprocal loss of desire on the part of others to take in Adam’s perspective. In this sense, both Adam and the meeting members had failed to fully profit from and complexify one another’s views. This, in certain ways, reminds us of Dougherty’s [41] “breakdowns in the perspective taking process due to the actor’s inability to surface and examine their differing interpretive schemes” leading to “unsuccessful cases of new product development”, whereby key players are unable “to reconcile their differences” [32, p. 358]. In this manner, their is a higher probability that potential technical (as well as financial, etc.) risks related to this engine rig testing project lie unaddressed; or worst new risks are created across individual cognitive assumptions that are not properly aired across the dialogical process previously described in figure 2.

The right side of figure 4 shows how a specific individual entering a discussion with the intention of imposing his/her views in a coercive sense-giving manner simultaneously displays an unwillingness to take in others’ perspectives. That person also becomes entrenched in his/her own self-creditation. All this implies an absence of mutual respect with others, while the general ambiguity of ‘emancipation of self’ vs
‘identity towards the other’ has been truncated down to a purely selfish ‘satisfaction of desire’.

Furthermore, as the left side of figure 4 shows via entrainment, others’ perspective-taking towards this person’s coercive sense-giving, begins to shutdown (and by extension involves the shutdown of all boundary constructions), thus severely limiting their perspective-making capabilities. In fact, others typically adopted a mirror-like defensive sense-giving behavior. Integration of rich complementary ambiguities is thus severely hampered, and hence, active readjustments in retained experiences and beliefs for all parties stop (resulting in mutually ‘frozen’ or entrenched positions of perpetual self-creditation). This dialogical breakdown leads to reduced complexification and sharing of knowledge, and simultaneously, in a general sense, increases the risk for undesirable consequences.

![Figure 4: Coercive sense-giving leading to reduced complexification of knowledge and increased risk.](image)

9. Conclusions

Our research first proposes, across discourse analysis, a dialogical knowledge construction process, which on the one hand, across emergent categories brings forth the notions of perspective-making/giving and perspective-taking at the interpersonal level whereby it describes the micro-interactions between individuals (as represented across Self and Other). This also includes the continuous revision of perspectives involving partial or full creditation, synthesis and discreditations that can range from being very incremental to almost ruptural in nature. In addition, we discerned and integrated into the dialogical process the concept of boundary constructions: here, rather than seeing objects as distinct end-resultant or static instruments being fully separate from the actor-subject, the dynamic and transient nature of the ‘object’ is more fully captured across an acknowledgement of the actor-object interaction, which in the end, is what vivifies and renders perspectives more easily understandable across the Others’ lenses.

The description of the dialogical knowledge construction process in terms of ‘why-it-occurs’ as such was basically addressed across our observation of how knowledge complexification involves a primary ambiguity or antithetical dyad at an ontological level whereby the Self and Other fully acknowledge and appreciate one another across the ‘recognition of individual Self-emancipation’ vs the ‘recognition of identity towards the Other’. This in turn is nurtured across feelings of mutual trust, mutual respect, mutual support and empathy – all very human traits, which we tend to forget and take for granted as we get caught up in the ‘mechanics’ of the process itself. It is across the presence of these two ontological yet antithetical elements that the Self attempts to place himself in the Other’s ‘shoes’ and vice-versa; and where individual learning and creation of new knowledge by both the Self and the Other can potentially occur. It is this ontological relationship between the Self and the Other which allows for specific secondary antithetical, yet complementary, knowledge to be expressed, integrated and synthesized within the dialogical process. The result is complexified knowledge. It is also where interrelated risks of all types can be mitigated. The alternative, that is when one or the other of the two primary ontological antithetical elements is repressed (typically across a lack of mutual respect, such as seen across a coercive Self or Other), renders all requisite variety (as represented across personal knowledge complementarities) as static and inert ‘elements’ that cease to be expressed or fail to interact with one another. Here, the dialogical process stops functioning in any authentic or veritable manner, thereby leading to a reduction in knowledge complexification and an increase in all manners of risk caused by breakdowns in authentic dialogue which, in the end, increase the likelihood of being unable to react, adapt or exploit a continuously changing and complex environment.

This single case study prevents us from generalizing our findings across the entire firm in question; and by extension, outside of the firm’s context. Additional workgroups/teams within the firm need to be evaluated; while similar studies in other institutions within the knowledge economy are to be envisaged.
10. References