



Joint Knowledge Base: A Key to Knowledge Sharing and Collaboration

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Abstract: Knowledge sharing is a key to successful collaboration (online or in presence), and since collaboration is changing due to the increasingly emerging so-called "New Collaboration," knowledge sharing should adjust accordingly: we call this New Knowledge Sharing. Organizations wishing to exploit the potential of New Collaboration need to understand how the new knowledge sharing and collaboration are related and, in particular, how they proceed, the very steps of their interwoven process. During our previous work, the concept of a Joint Knowledge Base (abbreviated to J.K.B.) emerged and became increasingly prominent as a key to knowledge sharing. Thus, in this paper, we will first revise and elaborate our concept of a J.K.B. in more detail. We will see how, on the one hand, when working on a shared task, each collaborator contributes to its construction and how, on the other, the J.K.B. functions as an interaction bridge, which is why it is a key to knowledge sharing. Secondly, we will describe different opportunities for partners in an interaction (team meeting, workshop, creative session, etc.) to contribute to the creation of a J.K.B. using so-called "Distributed Contribution Tools" (D.C.T.), which are standardized artifact-mediated interaction methods developed by E. Obeng. In particular, this second part will present 6 such D.C.T.s and explain how they contribute to the J.K.B. by means of a socially distributed production.

Keywords: Knowledge sharing, New collaboration, Joint knowledge base, Collaboration process, Artifacts-mediated interaction

1. Introduction

Collaboration, "the direct and mutually influential active confrontation of two or more people, oriented toward common goals, to solve or master a task or problem" (Stoller-Schai, 2021), is changing. A new way of collaborating is increasingly emerging. We call it "New Collaboration" (Bettoni et al. 2018). One main difference from traditional collaboration is that new collaboration is knowledge-based: it requires the individual knowledge of the collaborators to be integrated into a shared knowledge structure, which we have called a "Joint Knowledge Base" (J.K.B.). Organizations utilize only a tiny percentage of the potential of New Collaboration. The problem is that the new knowledge sharing, on which the collaboration is based, is challenging to understand. Firstly, you must be aware that a J.K.B. plays an essential role and take this seriously. Secondly, you must understand how to develop and maintain the J.K.B. and how the interwoven process between this J.K.B. and new collaboration works. Last but not least, you need to understand learning (and innovation in general) not only as a form of knowledge acquisition (cognitive process) and participation in a social community (social process) but also as collaborative knowledge creation (Paavola et al., 2004), a combination of cognitive and social processes, based on the notion that participation in social activities benefits cognitive processes (Du Chatenier et al., 2009).

2. Previous Work

Recently, in 4 E.C.K.M. papers (2017-2020), we developed a few foundations on which to base this understanding. We first looked at specific weaknesses in the conventional understanding of the concepts of "knowledge sharing" and "collaboration" and proposed some improvements (Bettoni et al., 2017). We then further elaborated on those

improvements and developed an understanding of the essence of collaboration that we called "knowledge-based and community-oriented" (Bettoni et al., 2018). The main difference between traditional and new collaboration lies in the fact that the task is no longer divided among the people who collaborate, and therefore, the required knowledge should also be unified; hence, the essential need to share the knowledge required to carry out the task among all the collaborators.

This notion enabled us during a third step to formulate the so-called Pyramid Principle of Collaboration, which claims that collaboration will be engaging, inclusive, empowering, and high-performance is organized according to a pyramid of seven layers (Bettoni and Obeng, 2019). Based on this structural model, we finally looked at some of its layers in more detail (Bettoni and Obeng, 2020). We argued that more than conversation is needed to exploit the potential of collaboration. We proposed the concept of artifact-mediated interaction (the third layer of the pyramid) as a solution to this problem.

In the following, we will revise and elaborate this interaction approach in more detail using two models: a cyclic model of individual knowledge construction called the Individual Knowledge Loop (I.K.L.) and a cyclic model of collaborative knowledge construction called the Collaborative Knowledge Loop (C.K.L.). These two models will enable us to deepen our understanding of how each collaborator in the interaction contributes to the construction of a J.K.B. and to suggest, on the other hand, how the J.K.B. functions as a basis for accomplishing the shared task.

3. The Construction of a Joint Knowledge Base

The term Joint Knowledge Base (J.K.B.) indicates the shared knowledge structure constructed and maintained during collaboration on a shared task (new collaboration). According to Roschelle and Teasley (1995:76), collaborators interact through language (conversation), physical action, and combinations of words and actions. During these collective activities, each collaborator contributes to the construction of the J.K.B. relating to the task at hand through their unique knowledge. Moreover, at the same time, the J.K.B. functions as a basis for accomplishing the shared task on which the group is working and can also be seen as an essential condition for transforming unique, individual knowledge into shared knowledge (Fig. 1). The J.K.B. collects and organizes a set of knowledge elements into a system which emerges during interaction as part of the group working together.

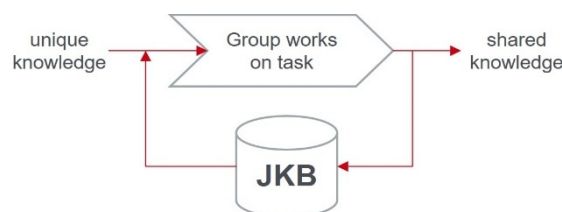


Figure 1: Group working on a task – a transformation from unique to shared knowledge

Laughlin (1980) proposed a group task continuum anchored in intellectual and judgmental tasks where intellectual tasks have a demonstrably correct solution. In contrast, judgmental tasks are evaluative judgments for which there is no generally accepted demonstrably correct answer. In the V.U.C.A. business world, more and more groups face knowledge-intensive tasks (Bettoni, 2000) that are judgmental rather than intellectual. In his study of group problem-solving, Laughlin (2011) further distinguishes 9 additional group task characteristics: additive, compensatory, conjunctive, disjunctive, complementary, divisible, unitary, maximizing, and optimizing. The new collaboration discussed in this paper involves knowledge-intensive, judgemental tasks that are also complementary (combine different abilities, skills, and knowledge), unitary (cannot meaningfully or efficiently be divided into subtasks and assigned to different group members), and optimizing (do not have objective suitability criteria).

3.1 A Cyclic Model of Individual Knowledge Construction

Before being shared, any knowledge element must be constructed by an individual group member (collaborator). Consequently, to understand knowledge sharing, we first need a process model for individual knowledge construction, at least a simple one—the construction of knowledge is an essentially cyclic process, like a control loop (learning loop). In fact, according to Piaget's theory of cognitive development (stage theory), knowledge begins to be developed during the first stage (birth to 2 years) through so-called sensorimotor learning, the essential dynamics of which are cyclic, a kind of control loop called a "circular reaction" (Piaget, 1936). For example, between 1 and 4 months, infants are interested in their bodies and try to reproduce an event they like (e.g., sucking thumb). These behaviors had been seen as

cyclic and called a "circular reaction" by Baldwin (1894) because the action produces the same stimulation, which triggers the same action. Piaget saw the importance of this cyclic concept and further developed it by introducing primary, secondary (4 to 12 months), and tertiary (12 to 18 months) circular reactions (Piaget, 1936). Later, through his concepts of equilibration and self-regulation (Piaget, 1967), he made circularity the foundation of his theory of knowledge, also called "constructivism."

Thus, our simplified model of individual knowledge construction will also be cyclic (Fig. 2). To keep it as practical and straightforward as possible (but not too simple), we will use a circular process as a basic configuration inspired by a famous, practice-oriented cyclic process: the so-called Deming cycle (Moen and Norman, 2009).

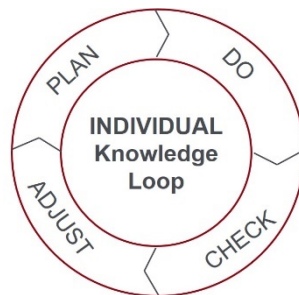


Figure 2: Cyclic model of individual knowledge construction (adapted from the Deming cycle).

According to this model that we call the Individual Knowledge Loop (I.K.L.), the construction of a knowledge element begins by planning (step PLAN) whereby expectations and other constraints are defined. During the second step (D.O.), the knowledge element is constructed. In the third step, its viability is then checked (step CHECK): Does it comply with the constraints of step 1, and is it consistent with the current individual knowledge base (I.K.B.)? If the knowledge element is viable, it will be introduced and assimilated as it is into the current I.K.B. Otherwise, further cycles will run (accommodation) during which the element itself will be modified (either by adjusting the planning or the doing), or else the I.K.B. will be adapted, and then viability will be rechecked. The cycle will repeat itself until the knowledge element is viable.

3.2 A Cyclic Model of Collaborative Knowledge Construction

When a group of collaborators come together and interact, they will bring with them and make use of their knowledge loops. In order to be consistent with these individual cycles, the collaborative knowledge construction should also be cyclic. Thus, we suggest a model of collaborative knowledge construction that is also cyclic and structured based on a loop of the same four steps: plan, do, check and adjust (Fig. 3). We call it a Joint Knowledge Loop (J.K.L.).

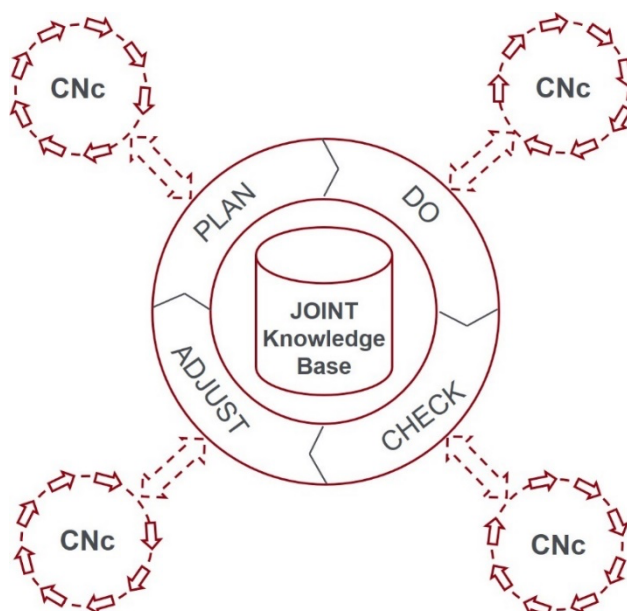


Figure 3: Cyclic model of collaborative knowledge construction

In order to engage all group members, each of the four steps of the J.K.L. should be spread across the turns of a "Contribution and Negotiation circle" (CNC): one after the other, each participant has the chance to provide their contribution to the step in hand. So, for example, the planning step is carried out via a sequence of turns whereby each participant can contribute some constraints and by a negotiation in which the group agrees on a shared version of the constraints.

Compared with the I.K.L., this Collaborative Knowledge Loop (C.K.L.) has three additional activities: 1) detecting divergence across collaborators by monitoring ongoing interpretations of knowledge elements and comparing them with the intended interpretations for determining whether these fit (CHECK step); 2) modifying existing elements when divergence arises during collaboration (ADJUST step); 3) rectifying intended interpretations when there are conflicts (meanings do not fit).

During such a collaborative construction (co-construction) of knowledge, each collaborator builds and maintains his/her knowledge base so that, in a group, we have as many knowledge bases involved as there are collaborators. However, the shared goal of working with the other collaborators on the same task leads to shared knowledge within these individual knowledge bases: knowledge that mutually converges (and resonates).

3.3 A Distributed Knowledge System

Thus, the Joint Knowledge Base does not exist in a single place; instead, it is a distributed knowledge structure of converging parts within the individually constructed knowledge elements. In our view, the I.K.B. and the J.K.B. are knowledge systems in the sense of Immanuel Kant's definition of knowledge: "A system of compared and connected mental constructs" (Kant 1781/1787, A97, own translation). Thus, an I.K.B. or a J.K.B. are much more than simply a repository and contribute a greater functionality to cognition than just a memory system.

In analogy with the Artificial Intelligence concept of a knowledge base (Feigenbaum, 1977), we suggest devising an I.K.B. and a J.K.B. as a system constituting two sub-systems: an Objects System (ObS) and a Methods System (MeS). The ObS collects and integrates the pieces of our individual experience, and the MeS collects and integrates structures, rules, action schemes, and all the other ways of connecting the pieces of the OBS. Together, the ObS and the MeS implement the essence of our experiential world: "The only world we consciously live in," based on the assumption that "The thinking subject has no alternative but to construct what he or she knows based on his or her own experience" (von Glasersfeld, 1995, p. 1). This experiential world is a system of experiential coherences "that the organism builds up to order the, as such, amorphous flow of experience by establishing repeatable experiences and relatively reliable relations between them" (Glasersfeld, 1984; Bettoni, 2007).

3.4 Shared Knowledge Element

When can we say that a knowledge element of an I.K.B. has become part of the J.K.B. and can be considered "shared"? In order to be accepted as constitutive parts of the J.K.B., knowledge elements must be evaluated as meaningful by the group. The meaning they must have is not simply a specific relationship between a sign and a reference (lexical meaning) or a grand principle of reason or ethics (philosophical meaning). They must make sense to the group in practical ways, especially about the professional experience of each group member. This is why the knowledge elements can enter the J.K.B. only if they successfully pass through a 'sensemaking' process called negotiation of meaning: an interactive process that comprises two highly interwoven activities, participation and reification (Wenger, 1998), which is the first of the two main components of cognitive presence (Bettoni et al., 2018). In short, the element of an I.K.B. of any group member must go through a process of group cognition and can enter the J.K.B. only as a socially negotiated result of this process. When the negotiation of meaning succeeds, this leads to the emergence of knowledge areas among the group members that converge and resonate: the elements of these areas can then be considered as "shared" knowledge elements.

The fact that two or more individual knowledge elements are seen as converging does not necessarily imply that they overlap or match in all their parts and across all the individual knowledge bases of the group members. It is sufficient if they fit the purposes at hand. In this sense, we should speak more precisely of taken-as-shared rather than shared knowledge elements (Cobb, 2000, p. 166). It is in this sense that we speak of a "joint" knowledge base: the J.K.B. is the distributed system of those knowledge elements whose meanings converge and fit across group activities and enable

meaningful conversation, action, and interaction in relation to the purposes which emerge step by step during collaboration on a shared task.

4. Boundary Objects

Collaboration will become more successful if the J.K.B. becomes more and more representative of the group's knowledge. When co-constructing such a representative J.K.B., the four steps of the C.K.L. must be distributed across the turns of 4 Contribution and Negotiation circles (see Fig. 3), and this is not easy to achieve! When people engage in conversations and debates for contributing knowledge elements and negotiating their meaning, one of the main difficulties is represented by an obstacle called the "semantic boundary," one of three types of knowledge boundaries (Carlyle, 2002). Even if a shared language is present, which enables the syntactic boundary to be overcome, "interpretations are often different" (Carlyle, 2002, p. 444). Interpretations are different because differences in experience among participants have created different experiential worlds (von Glasersfeld, 1991) and these lead to different conceptualizations and interpretations. Thus, more than conversation and debate is needed to make communication and collaboration successful during a C.K.L.

How could we overcome the semantic boundary? When studying heterogeneous problem-solving by scientists of different disciplines, Star (1989) observed that they were nonetheless able to successfully collaborate and attributed this to what she called "boundary objects": objects that enabled those scientists to establish shared context (Star, 1989, p. 47) like, for instance, artifacts, documents, terms, standardized forms and methods, models and other forms of reification (Wenger, 1998, p. 105).

5. Distributed Contribution Tools (D.C.T.)

By considering boundary object research as well as its various applications to knowledge interactions (Carlyle, 2002; Huang and Huang, 2013) and from our own experience with the Q.U.B.E. system (a 3D collaborative virtual environment) (Pentacle, 2019), we have been able to see in a new light the Performance Enhancing Tools (P.E.T.s) developed by E. Obeng for the Q.U.B.E. system (Obeng, 1994; Obeng, 2003; Obeng and Gillet, 2008): we now see a QUBE PET as a boundary object, more specifically as a Distributed Contribution Tool (D.C.T.).

A DCT is a standardized, artifact-mediated interaction method composed of a pinboard, a kind of poster (see Fig. 4, 5, 6), and documentation that describes "what is it?" "Why do I need it?", "When do I use it?" and "How do I use it?" It corresponds to a collaboration pattern in literature (Eppler and Schmeil, 2010). What is unique about a D.C.T. is that the collaboration involved is always an artifact-mediated interaction (at the pinboard) and that it functions as a boundary object, thus enabling collaborators to establish shared context and to contribute to the steps of a C.K.L. Interaction using a D.C.T. follows the Metaplan technique (Schnelle, 1978) where collaborators meet in front of a panel which holds a structured pinboard (poster); all the participants write their ideas on cards, place the cards on suitable areas of the panel, point to items and ask questions or explain their ideas. A group member acts as a facilitator for the conversation and organizes the cards into clusters accordingly.

To construct a representative J.K.B., more is needed to establish shared context among participants; you also need to lead and facilitate the interactions so that each group member can contribute, feels included, and becomes emotionally engaged (socially distributed contribution). This can be supported by traditional facilitation tools (Kaner, 2014), but more than this facilitation is needed. We need to include boundary objects by means of a more systematic approach. Thus, in our approach, we suggest using a well-selected sequence of boundary objects of the Q.U.B.E. system during a group meeting where each functions as a D.C.T.

During a collaboration event, each D.C.T. provides a generic set of knowledge elements (ObS and MeS) based on the structure of its pinboard (see Fig. 4, 5, and 6), which function as catalyzers of the interaction, thus guiding the construction of shared knowledge elements along clearly defined pathways and making the negotiation of meaning more efficient and effective.

A well-designed collaboration event should start with inclusion, should provide orientation, must be aware of any affected stakeholders, needs to consider the involved change, requires actions to be taken, and should finally be assessed

(evaluated). Based on this generic collaboration framework of six steps, we have selected a standardized method of Q.U.B.E. for each step as a suitable D.C.T. (boundary object):

- For inclusion and orientation: Hopes&FearsTM and 5PsTM;
- For stakeholders and change: FindingStakeholdersTM and GapLeapTM;
- For action and assessment: StickyStepsTM and Here2ThereTM.

5.1 Inclusion

The D.C.T. called Hopes&FearsTM (Fig. 4) has a pinboard divided into three fields: on the left, a box for the fears; on the right, a box for the hopes; and below, a box for ways for overcoming the fears. This is a great way to initiate any new activity with stakeholders, especially if there is much uncertainty in the goals or methods.

Working with this D.C.T. helps with the first steps of inclusion in teambuilding; it contributes to emotionally engaging team members from the start, helping them to define shared goals, agreeing early on what does and does not fall within the scope, agreeing on what is hard and what are soft success criteria, identifying risks and creating the basis for a typical project culture. This D.C.T. should be used at the start of any meeting with new or existing stakeholders (especially where there is uncertainty).

5.2 Orientation

The D.C.T. called 5PsTM (Fig. 4) provides a way of formulating the essential aspects of a message, task, or action. The pinboard is divided into two fields. The box on the left is for the unstructured, spontaneous description of an idea, message, or task. The box on the right is structured into five fields: Purpose, Principles, People, Process, and Performance.

Working with this D.C.T. helps to avoid misunderstandings and communicate clearly about complex issues, like the core elements of a project, problem, or solution. It should be used at milestones when the group needs to reflect on the project, task, or action and gain a clearer view of its essential aspects, as well as every time a team member or stakeholder receives instructions to act independently.

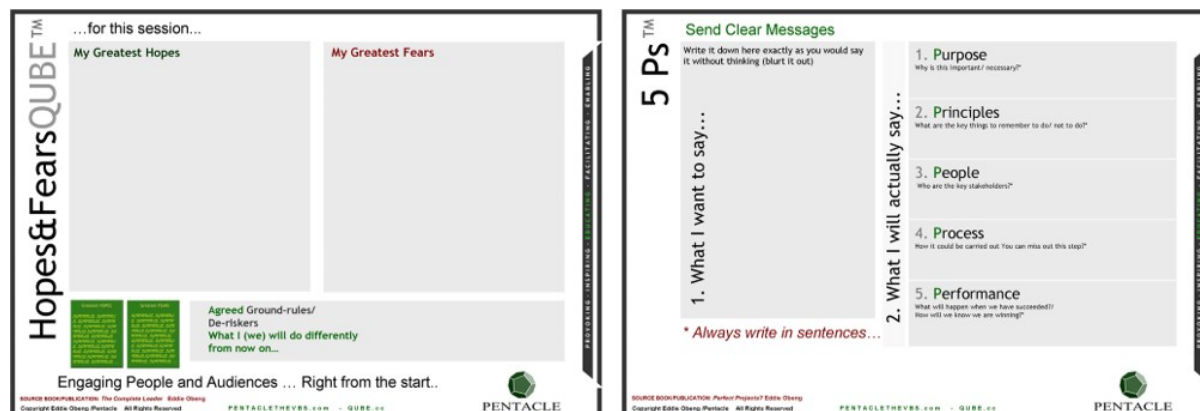


Figure 4: Boundary objects for inclusion and orientation (www.pentacle.co.uk)

5.3 Stakeholders

The pinboard of the D.C.T. FindingStakeholdersTM (Fig. 5) shows a typical "window," an area divided into four equal sub-areas. The two columns distinguish two main categories: A) people who will benefit from the project or action and B) people whom the project or action will damage. Then, the two horizontal rows further divide the two groups by distinguishing whether the project 1) could happen without them or 2) could not without them. This D.C.T. is a quick way to identify the relevant stakeholders and ensures you will never surprise them. It should be used at the start of the project and all subsequent review points when looking at additional activities needed to deliver the overall project.

5.4 Change

The GapLeap™ pinboard (Fig. 5) is divided in the middle into two main horizontal areas using a row called the "gap."

"This is an area for expressing the difference between the current and the envisaged situation in a short statement. The top left area, IF NOT FIXED, establishes what will happen if the current situation remains unchanged, and the top right area for what will happen if the envisaged situation is implemented. The area below the middle row requires a reason why the gap must still be fixed. After entering their contributions in the four areas, the facilitator will invite the team to decide on a time horizon, assign costs, and calculate the difference between the costs of IF NOT FIXED and IF FIXED. In a fast-changing, complex world, a team often identifies the need for change. This D.C.T. provides a way of becoming aware of that change and gaining a broad understanding of why change needs to happen and what specifically needs to be done. It should be used every time a team needs to test or justify the need for change and has to present financial numbers or benefits for its business case.

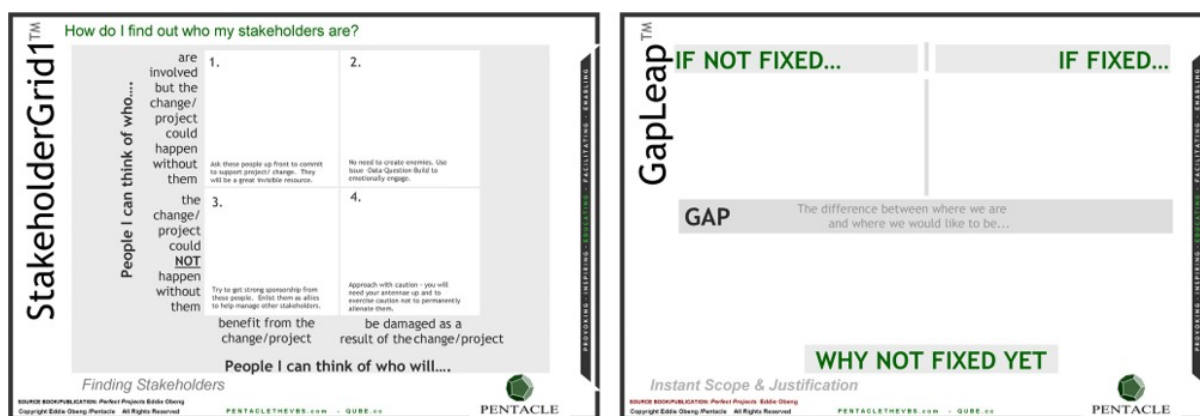


Figure 5: Boundary objects for stakeholders and change (www.pentacle.co.uk)

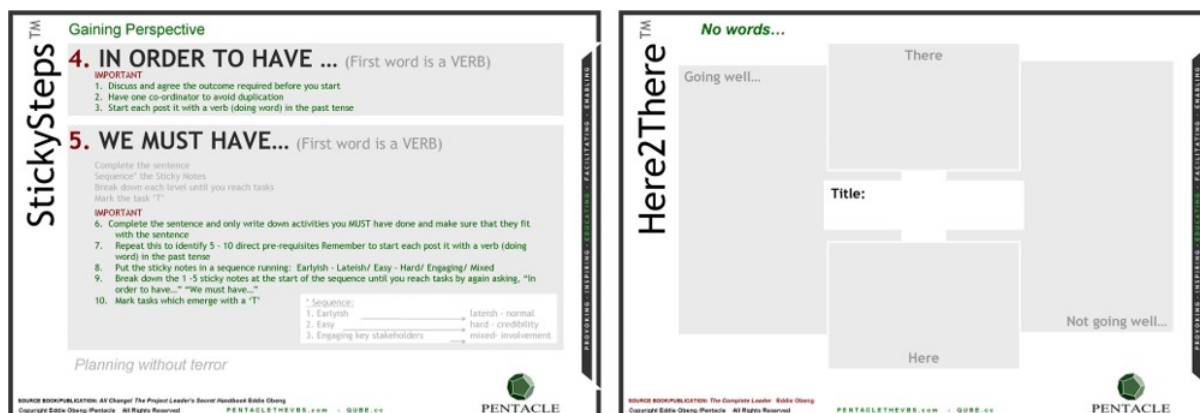


Figure 6: Boundary objects for action and assessment (www.pentacle.co.uk)

5.5 Action

The D.C.T. called StickySteps™ (Fig. 6) displays a simple pinboard with just two areas: a row on the top for expressing the overall goal and a large area below this row for breaking down the overall goal of the action into the means required to achieve it. If one or more actions in this lower area are still too large, the team repeats this step by adding a lower breakdown level; the breakdown continues until you reach tiny, little steps (tasks). This D.C.T. provides a quick and effective way to plan a project or action whenever they are almost too large to contemplate. This kind of breakdown (goal to action) allows interdependencies between parts of the project, action, or task to be dealt with appropriately.

5.6 Assessment

The Here2ThereTM pinboard (Fig. 6) offers four equal areas on three levels for performing a quick progress review to be used at frequent, short review events, for instance, in regular, weekly meetings when the team wants to update every member on the principal outcomes. No words are allowed! The participants are advised to use images and metaphors to describe: 1) their current state (field "Here"); 2) where their journey should end (field "There"); 3) what is not going well; 4) what is going well.

6. Conclusion

During collaboration on a shared, unitary task (new collaboration), a distributed knowledge structure is constructed, maintained, and shared: a Joint Knowledge Base (J.K.B.). It collects and organizes into a system a set of shared knowledge elements that emerge during interaction within a group working together on a knowledge-intensive group task. Thanks to this, the J.K.B. facilitates communication and collaboration: it functions as an interaction bridge.

However, making such a bridge representative of the group's knowledge takes work! As a solution to this problem, we have suggested: a) a cyclic model of collaborative knowledge construction; b) the Contribution and Negotiation circle as the interactive process a knowledge element must go through in order to be allowed to enter a J.K.B.; c) an inner structure of the J.K.B., distinguishing pieces of knowledge (Objects System, ObS) and ways of connecting these pieces (Methods System, MeS); d) Distributed Contribution Tools (D.C.T.) as boundary objects that enable group members to establish shared context by means of artefact-mediated interaction.

A set of six D.C.T.s (for inclusion, orientation, stakeholders, change, actions, and assessment) has been presented, which makes it possible to see how, in principle, to structure a well-designed collaboration event as a sequence of artefact-mediated interactions. The D.C.T.s, based on the structure of their pinboard, provide an initial set of explicit knowledge elements (ObS and MeS) that all group members can use as demarcations guiding the flow of the interaction. This channels the construction of shared knowledge along explicitly defined pathways, thus making the Contribution and Negotiation cycles more efficient and effective. Eventually, this leads to a distributed Joint Knowledge Base representing the group's knowledge.

References

- Baldwin, J. M. (1894). "Imitation: A Chapter in the Natural History of Consciousness," *Mind*, (London), Jan. 1894. [CrossRef](#)
- Bettoni, M. (2000). Meeting the Challenge of Knowledge-Intensive Automation. Presentation at CAWorld 2000,
- Neugents Session, April 10, New Orleans. Online: <http://www.weknow.ch/marco/A2000/CAWrld/index.htm>
- Bettoni M. (2007). Knowledge as Experiential Reality. *Constructivist Foundations*, Vol. 3, number 1, 10–11. <http://www.univie.ac.at/constructivism/journal/3/1/010.bettoni>
- Bettoni, M., Obeng, E., Bernhard, W., Bittel N. & Mirata, V. (2017). The Importance of Space in Knowledge Sharing Online: The Q.U.B.E. Approach. In F. Marimon, M. Mas-Machuca, J. Berbegal-Mirabent & R. Bastida (eds.) *Proceedings of the 18th European Conference on Knowledge Management E.C.K.M. 2017*, Universitat Internacional de Catalunya, Barcelona, Spain, 7-8 September 2017, Vol. 1, pp. 122-129
- Bettoni, M., Bernhard, W., Bittel, N. and Mirata, V. (2018). The Art of New Collaboration: Three Secrets. In: E. Bolisani, E. Di Maria, & E. Scarso (eds.) *Proceedings of the 19th European Conference on Knowledge Management (E.C.K.M. 2018)*, University of Padua, Italy, 6-7 September 2018, Vol. 2, pp. 1133-1141.
- Bettoni, M., & Obeng, E. (2019). The Pyramid Principle of New Collaboration: Inner Workings of the Process of Collaboration. In: E. Tomé, F. Cesario & R. Reis Soares (eds.) *Proc. of the 20th European Conf. on Knowledge Management (ECKM 2019)*, Universidade Europeia de Lisboa, Lisbon, Portugal, 5–6, 9.2019, Vol. 1, 122-131. [CrossRef](#)
- Bettoni, M. & Obeng, E. (2020). Alive by Meeting: A Solution to the Paradox of Meetings by means of the Pyramid of New Collaboration. *Electronic Journal of Knowledge Management (E.J.K.M.)*, Volume 18, Issue 2, pp. 161-171 <http://www.ejkm.com/>

- Bettoni, M. & Obeng, E. (2020). New Collaboration is Knowledge-Based: What, Why and How. In: A. Garcia-Perez & L. Simkin (eds.) Proc. of the 21st European Conference on Knowledge Management (E.C.K.M. 2020), Virtual conference supported by the University of Coventry, UK, 2-4.12.2020, Vol. 1, 89-98.
- Carlile, P.R. (2002). A pragmatic view of knowledge and boundaries: boundary objects in new product development, *Organization Science* 13 (4), 2002, 442–455. [CrossRef](#)
- Cobb, P. (2000). Constructivism in Social Context. In: L.P. Steffe & P.W. Thompson, *Radical Constructivism in Action. Building on the Pioneering Work of Ernst von Glasersfeld*. London: RoutledgeFalmer.
- Du Chatenier, E. Verstegen, J.A.A.M., Biemans, H.J.A., Mulder, M. & Omta, O. (2009). The Challenges of Collaborative Knowledge Creation in Open Innovation Teams. *Human Resource Development Review* 2009; 8; 350-381. [CrossRef](#)
- Eppler, M.J. & Schmeil, A. (2010). Visual Collaboration and Learning Patterns in 3D Environments: Emergence, Elements, Examples. In: T. Hug & R. Maier (Eds.) *Medien – Wissen – Bildung Explorationen visualisierter und kollaborativer Wissensräume*. Innsbruck: Innsbruck University Press.
- Feigenbaum, E. (1977). The art of artificial intelligence: themes and case studies of knowledge engineering. In: Proc. of the 5th Int. Joint Conference on Artificial intelligence (IJCAI'77), Volume 2, August 1977, 1014–1029.
- Glasersfeld, E. von (1984) An introduction to radical constructivism. In: Watzlawick, P. (ed.) *The invented reality: How do we know?* W. W. Norton: New York, pp. 17–40.
- Glasersfeld, E. von (1991) Knowing without Metaphysics: Aspects of the Radical Constructivist Position. In: F. Steier (ed.) *Research and reflexivity*. London: Sage, 12–29.
- Glasersfeld, E. von (1995) *Radical constructivism. A way of knowing and learning*. London: Falmer Press.
- Huang, E.Y. & Huang, T.K. (2013). Exploring the effect of boundary objects on knowledge interaction. *Decision Support Systems* 56 (2013) 140–147 [CrossRef](#)
- Kaner, S. (2014). *Facilitator's Guide to Participatory Decision-Making*. San Francisco: Jossey-Bass.
- Kant, I. (1781/1787). *Kritik der reinen Vernunft* (Critique of pure reason, Translation N.K. Smith, St. Martin's, New York, 1965), Riga, 1781 (1st edition, A) and 1787 (2nd edition, B), I. Heidemann (Ed.) Stuttgart: Reclam.
- Laughlin, P.R. (1980). Social combination processes of cooperative problem-solving groups on verbal intellectual tasks. In M. Fishbein (ed.), *Progress in Social psychology*. Hillsdale, NJ: Erlbaum, 127-155.
- Laughlin, P.R. (2011). *Group problem solving*. Princeton: Princeton University Press. [CrossRef](#)
- Moen, R. & Norman, C. (2009). Evolution of the PDCA cycle. Paper delivered to the Asian Network for Quality Conference in Tokyo on September 17, 2009. Retrieved 19.3.2021.
- Obeng, E. (1994). *All Change! The Project Leader's Secret Handbook*. London: Pitman Publishing.
- Obeng, E. (2003). *Perfect Projects*. Beaconsfield: PentacleWorks.
- Obeng, E. & Gillet, Ch. (2008). *The Complete Leader. How to Lead to Results*. Beaconsfield: PentacleWorks.
- Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of Innovative Knowledge Communities and Three Metaphors of Learning. *Review of Educational Research*, Winter 2004, Vol. 74, No. 4, 557-576.
- Pentacle (2019) Frequently asked commercial, user concern and technical questions. Downloaded 31.3.2019: <https://pentacle.co.uk/Downloads/DueDiligenceFAQSummary.pdf>
- Piaget, J. (1936) *La naissance de l'intelligence chez l'enfant*. Neuchâtel: Delachaux et Niestlé, 9th edition 1977. English: *The origins of intelligence in children*; translated by Margaret Cook., New York: International Universities Press, 1966.
- Piaget, J. (1967) *Biologie et connaissance. Essai sur les régulations organiques et les processus cognitifs*. Paris: Gallimard.
- Roschelle, J., & Teasley, S. D. (1995). "The construction of shared knowledge in collaborative problem solving". In: C. E. O'Malley (Ed.), *Computer-Supported Collaborative Learning* (pp. 69–197). Berlin: Springer-Verlag. [CrossRef](#)
- Schnelle, E. (Hrsg.) (1978) "Neue Wege der Kommunikation. Spielregeln, Arbeitstechniken und Anwendungsfälle der Metaplan-Methode". *Veröffentlichungen der Stiftung Gesellschaft und Unternehmen* (in German). Königstein/Ts.: Peter Hanstein Verlag. Heft 10.

- Star, S. L. (1989). The structure of ill-structured solutions: Boundary objects and heterogeneous distributed problem solving. In: M. Huhns & L. Gasser (eds.) Readings in Distributed Artificial Intelligence. Menlo Park, CA: Morgan Kaufman, Chapter 2, pp. 37–54. [CrossRef](#)
- Stoller-Schai, D. (2021). Making Collaboration Work. In: S. Güldenbergl et al. (eds.), Managing Work in the Digital Economy, Future of Business and Finance. Cham: Springer Nature Switzerland AG. [CrossRef](#)
- Wenger, E. (1998). Communities of practice: Learning, meaning and identity. Cambridge, UK: Cambridge University Press. [CrossRef](#)