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The Pyramid Principle of New Collaboration

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Abstract: The Pyramid Principle says that online collaboration will be engaging, inclusive, empowering and high-performance if it is organized according to a pyramid of seven layers (elements), with knowledge sharing as the next layer below collaboration and with physical space (real or virtual) as the largest, most fundamental layer at the bottom of the pyramid. Knowledge sharing is the key to successful online collaboration and space, which underlies all thoughts – according to Immanuel Kant - is what provides a stable ground for the 5 upper layers on which online collaboration, at the top of the pyramid, must be based. Our paper will first review related literature dealing with knowledge sharing and its relevance to collaboration. Then, in the central part, we will explain in detail the Pyramid Principle and its seven layers. Finally, we will analyze and compare two types of commercial platforms (2D and 3D) for synchronous digital collaboration, focusing on how well they contribute to implementing the Pyramid Principle.

Keywords: knowledge sharing, new collaboration, collaboration process, collaborative patterns, digital collaboration.

1 Introduction

Collaboration may appear to be easy but it is not! Our aim in this paper is to overcome this illusion by referring to a model of the inner workings of the collaboration process. We hope that this will help with taking the complexity of the collaboration process seriously and devising ways and tools for better exploiting the potential of digital online collaboration so that it becomes engaging, inclusive, empowering and highly effective. In the introduction, we will present those aspects of collaboration which need to be better understood. Knowledge sharing is one of these: thus, in the 2nd and 3rd section we will introduce the concept of a "Joint Knowledge Base" (JKB) and demonstrate how collaboration is based on knowledge sharing. Section 4 will then introduce a Pyramid, our model of the inner workings of the collaboration process (a means-end hierarchy) and explain its 7 levels. Then, in section 5, drawing on the JKB and Pyramid, we will be able to explain some essential internal aspects of the collaboration process and finally in section 6, our model will be applied in comparing 2D and 3D commercial platforms, focusing on how well they contribute to implementing the Pyramid Principle. Collaboration is not easy because we do it without sufficiently understanding its complexity; and we do not try to sufficiently understand it precisely because it seems to be easy. A deadlock! Since we are not aware of being trapped in such a deadlock, no platform, no software, no artificial intelligence will ever help us to get out; we must try to reflect more deeply on collaboration, especially Digital Collaboration and perseverate unless we succeed in better understanding it. For successful Digital Collaboration (online, remote collaboration, e-collaboration) there is a need to interact synchronously and asynchronously. These online interactions can basically take the form of two types - talking and accomplishing: 1) talking about a task (communication such as open discussion, presentations, reports, etc.); 2) accomplishing a task (collaboration such as brainwriting, multi-station visits, posting sticky notes on a panel, breakout groups, gallery tour, tradeshow, roleplays, etc.) In a world of volatility, uncertainty, complexity and ambiguity (VUCA), the second type of interaction, accomplishing a task collaboratively, is becoming more and more important. For this remote collaboration scenario to be successful, there is a need to enable all its participants to share content and modify the shared content as well as to communicate while doing so [1]. Unfortunately, we do not sufficiently understand these needs or the related process of collaboration or the new role that knowledge sharing, negotiation of meaning, the co-construction of knowledge and other essential activities and resources are playing in this process which mean that collaboration is changing and emerging increasingly as what we call "New Collaboration" [2]. One essential aspect of New Collaboration which we should understand and take seriously, especially for online collaboration, is its relationship with knowledge sharing. Understanding this would enable us to better exploit the potential of online collaboration for delivering successful results in the VUCA world. It is here where our Pyramid Principle of New Collaboration comes in as a conceptual tool for understanding knowledge sharing, its prerequisites and its role in

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digital collaboration. The Pyramid Principle allows to clarify: 1) how sharing knowledge is deeply grounded in space [3]; 2) the new role of knowledge sharing in supporting online collaboration; 3) why 2D-platforms and other tools for synchronous online interactions like video-conferencing do not allow efficient and effective online collaboration. These clarifications would enable us to dramatically improve the design and practice of online interactions, especially virtual team collaboration and online project work

2 Collaboration and Knowledge Sharing: Related Work

Little is known about how collaboration and knowledge sharing actually proceed. In organizational and educational contexts, research focuses mostly either on outcomes or on "external" aspects as conditions for successful outcomes of collaboration and knowledge sharing such as cognitive, social and emotional aspects [4], corporate culture [5] or interpersonal, team, individual, motivational and cultural factors [6]. Similar types of external factors have been addressed in a recent comprehensive model of knowledge sharing which focuses on "*environmental forces, knowledge values of the organization, cultural and structural characteristics of the organization, personal characteristics of the individuals, teams and the context within the organization*" [7]. These areas of insight are useful and necessary but they do not explain how collaboration actually proceeds. In order to know how to design the process itself, we need to shed light on the black box and on its internal workings (see Fig. 1). We believe that focusing on two internal aspects of collaboration and knowledge sharing, concept (what) and process (how), is of at least equal if not greater importance than studying external factors and outcomes.

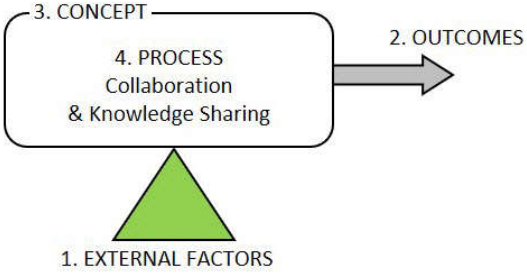

Fig. 1: Four main aspects of collaboration & knowledge sharing:
1. External factors, 2. Outcomes, 3. Concept, 4. Process.

Before analyzing the process of collaboration, it is useful to clarify our concept of collaboration, i.e. what kind of activity we are seeking to understand. Our concept of collaboration is knowledge-based and community-oriented: we call it "New Collaboration" [2] and it is not just an abstract idea; in fact, it is already happening in practice although we are not aware of it [8, 9]. In the VUCA world, successful people collaborate in a new way: they work together on a task without splitting it. And because the task is not split, the related knowledge needed during the performance of the task must also build a unit and be maintained as a unit. For this reason, new collaboration must be knowledge-based. Moreover, since keeping this task-related knowledge as a unit requires the mutual engagement of the group in a conscious, continuous effort to construct and maintain this unit as a shared knowledge structure, new collaboration must also be community-oriented. This is summarized in the following definition [2]: New Collaboration is a coordinated activity between persons who interact (online or in presence) for working together at the same, single task and who, concurrently, are also mutually engaged as a community in a conscious, continuous effort to construct and maintain an underlying shared knowledge structure as a basis for accomplishing their task (see Fig. 2). This definition, which tightly binds collaboration and knowledge sharing, has its roots in the seminal work by Roschelle & Teasley [10] which almost 25 years ago investigated collaborative problem solving. In their definition, "*Collaboration is a coordinated … activity that is the result of a continued attempt to construct and maintain a shared conception of a problem*" [10]. Based on our definition of collaboration, the analysis of the process of collaboration, for example collaboration by a project team, can be split into two areas of inquiry:

- Analysing how team members interact for dealing with task T (planning, design, problem solving, etc.)
- Analysing how team members construct and maintain a shared knowledge structure relating to that task T.

Again, like with our concept of collaboration, for our analysis of the process of collaboration we will also use the framework developed by Roschelle & Teasley [10:75 ff] as a source of inspiration but suggest some modifications. Notice moreover that, like Roschelle & Teasley, we also make a distinction between the terms *collaboration* and *cooperation*. We use the term "cooperation" when working together is accomplished through a division of labour among participants whereby the task is split into pieces and each person is responsible for one piece [10:70]. Collaboration is a different concept: the task is not split, it remains as a single unit; each participant works on the whole task and is responsible for it as a whole [11:123]. The notion of a "shared knowledge structure", which Roschelle & Teasley call "Joint Problem Space (JPS)", is central to their approach which proposes that the fundamental activity of the process of collaboration "*occurs via engagement with an emergent,*

socially negotiated set of knowledge elements that constitute a Joint Problem Space" [10:70].

3 Joint Knowledge Base (JKB)

Because of the term "problem space", the concept of a JPS could be wrongly associated with the Artificial Intelligence concept of problem space as originally introduced by Allan Newell and Herbert Simon in their general theory of problem solving [12, 13]. As part of this theory, they assume that people solve problems based on a process characterized by a "search" within a problem space. The problem space represents the problem by means of "states of knowledge", the initial (current) state, the goal state and all possible states in-between which can be huge in number; domain knowledge and heuristics help people navigate their way through all the possible knowledge states. This approach worked only for very constrained "toy domains" (blocks world) and failed in real-world domains but contributed to highlighting the importance of task-specific, expert knowledge [14] and to promoting the idea that intelligent systems derive their power from the specific knowledge they possess rather than from general search algorithms. As a consequence, in the 1980s AI changed its focus from search systems and general problem solvers to knowledge representation and knowledge-based systems, for example specialized expert systems which could match human competence on a specific task (medical diagnosis, computer configuration, molecules identification, etc.).

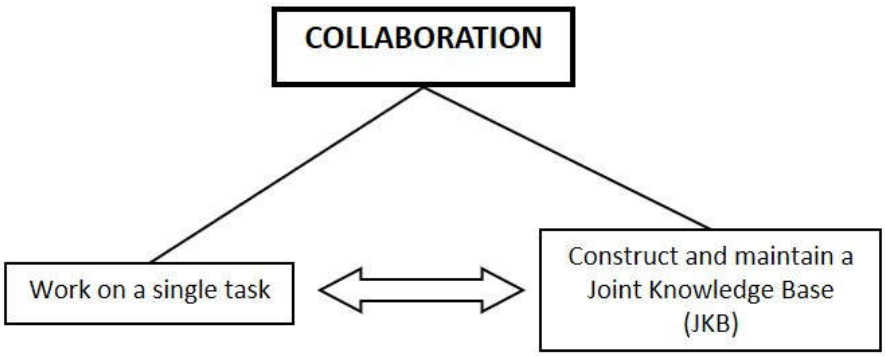

Fig.2: Concurrent, co-existing and connected activities which constitute the process of collaboration.

In order to avoid misunderstandings and against the background of our own experience with knowledge engineering and the development of expert systems [15, 16] we suggest substituting the term Joint *Problem Space* and introducing instead the term "Joint *Knowledge Base*" to indicate the shared knowledge structure which each team member constructs and maintains in his/her mind during collaboration. Collaborators interact by conversation, physical action and interaction (combinations of words and action). During these activities, each collaborator contributes to the construction of the JKB relating to the task at hand. And at the same time, the JKB functions as a basis for accomplishing the task on which the team is working (see Fig. 2) and can also be seen as an essential condition of the possibility of successful collaboration. The JKB collects and organizes into a system a set of socially negotiated knowledge elements which emerge during interaction within the group which is working together to accomplish the shared task.

4 The Pyramid of New Collaboration

After having seen that collaboration is based on knowledge sharing, the question which naturally arises is "How does the process of knowledge sharing proceed?" We have suggested in our Presence Model of Knowledge Sharing [3:170] that a successful knowledge sharing experience occurs through the integration of three essential elements: cognitive presence, social presence and leading presence, an approach inspired by the Community of Inquiry (CoI) framework [17] and consistent with Barron's dual space model of collaboration which differentiates between the social and cognitive aspects of collaboration [18]. In our model of 2018, the point of view was based on aggregation in a hierarchy of parts (or steps) required for the process. Here we want instead to consider how the components of this model enable each other as *foundations* within a hierarchy or pyramid of means and ends (Fig. 3). This approach is inspired by the means-ends hierarchy of Systems Engineering where it is used as a way of organizing systemic objectives [19] and by the goals breakdown structure (GBS) of Project Management [20]. Each level of the pyramid is both an end and a means (means-ends duality): it's an end, if referred to the level below it and a means in relation to the level above it. Thus, when considering two adjacent levels, for example the upper two, you can say: we share knowledge (level 6) *in order to* (end) collaborate (level 7) and we collaborate *by means*

of sharing knowledge (level 6).

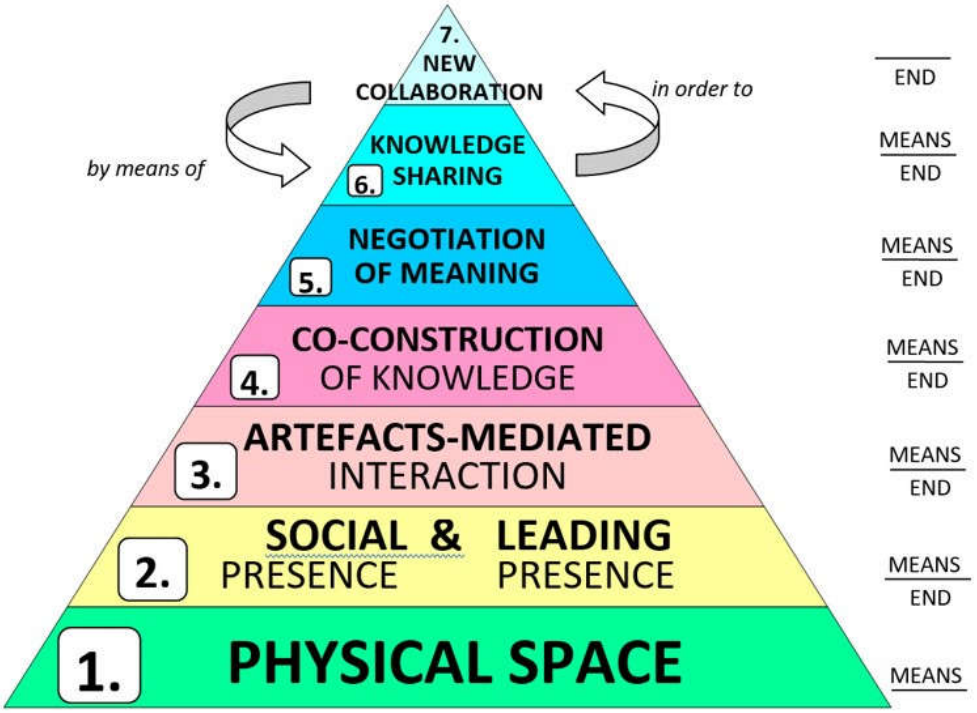

Fig. 3: The Pyramid of New Collaboration (PNK).

Level 7 – New Collaboration. The top of the Pyramid of new collaboration consists of the process of collaboration, our highest goal. If we want to better exploit the potential of online collaboration for delivering successful results in the VUCA world then we need to better understand the dynamics of collaboration (see Fig. 2) and that is why we look at the foundations below it, beginning from level 6 and then going down, until we reach the ground (level 1).

Level 6 – Knowledge Sharing. Knowledge Sharing is the fundamental activity which enables New Collaboration and that is why we find it immediately below level 7. This is where collaborators construct and maintain the Joint Knowledge Base, a knowledge structure which is consistent with the previously mentioned socially negotiated set of knowledge elements as suggested by Roschelle & Teasley [10:70]. But how do they do this? What is required for constructing a JKB? To answer these questions, we move to level 5.

Level 5 – Negotiation of Meaning. Because shared knowledge requires socially negotiated meanings, the means which most directly contributes to the end of knowledge sharing is that of negotiation of meaning, one of the two main components of cognitive presence. This is hence level 5 of the pyramid. Negotiation of meaning enables the creation of a socially negotiated JKB. Negotiation of meaning within a group or community is a process comprising participation and reification [21]. Wenger's model highlights the importance of thinking of the experience of meaning as a unity of two distinct elements which are tightly interwoven but distinct; participation refers to a process of taking part with others in some activity and recognising ourselves in each other, whereas reification according to Wenger [21: 58] refers to the process of giving form to our experiences by producing related objects.

Level 4 – Co-Construction of Knowledge. Given this model of negotiation of meaning, it follows that to determine the levels of the pyramid underlying level 5, we need to find means for implementing participation and reification as ends. Participation must be about something, some content, ideas, proposals; and reification also must be of something. So, what we need here in first place is to produce relevant content, hence to be creative and skilled in constructing (producing or modifying) knowledge. Thus, level 4 of the pyramid is constituted by the co-construction of knowledge, the second main component of cognitive presence. This level comprises skills like: (a) shared language, (b) shared content / storage, (c) co-planning, (d) co-solving, (e) co-writing [2:1137].

Level 3 – Artefacts-Mediated Interaction. What could be a good way to make the co-construction of knowledge successful?

In their collaboration research, Roschelle and Teasley [10:76] mention language, physical action and combinations of words and actions as three types of general activities which constitute the process of collaboration. The idea is that collaborators do not simply talk; they also need to do something physically. In knowledge work, this opportunity could be provided by a computer-based environment, like for example the direct manipulation graphical simulation environment called "Envisioning Machine" used by Roschelle & Teasley [10:71-ff]. A simpler and very generally applicable way of making a physical interaction happen within a group of knowledge workers (breakout group or plenary group) is the Metaplan technique [22] which uses a pin board (a panel) and cards as artefacts for mediating the interaction of the team which is co-constructing knowledge. Collaborators meet at a board which can be blank or structured (see Fig. 4) and which can hold cards (with text or images); they interact by first writing their ideas on the cards, then placing them on the panel and furthermore by organizing the cards into clusters, by pointing to items and asking questions or by explaining their own ideas. All these modes and means of interaction provide resources which make knowledge sharing possible (enable) and mediate collaboration. Thus, artefacts-mediated interaction becomes level 3 of our pyramid.

Fig. 4: Artefact-mediated interaction: pin board (panel) called "Hopes and Fears" © Pentacle.

Level 2 - Social Presence & Leading Presence. Now we come to the two lower levels of the pyramid, those which provide a stable ground to the whole building. What happens when people interact at a pin board and what could be a good foundation for making their panel interaction successful? In our model, this is provided by leadership presence and social presence [3]. *Social presence* is defined as the extent to which the participants of the collaboration succeed in projecting their personal characteristics onto the group (team, community), thereby presenting themselves to the other participants as "real people". They do this mainly by expressing emotions (closeness, humor, self-disclosure), by open communication (mutual awareness, recognition) and by contributing to group cohesion (empathy, participation). *Leading presence* is defined as the design, facilitation and support of the cognitive and social presence (of the related processes) for achieving personally meaningful and organizationally worthwhile collaborative outcomes.

Level 1 – Physical Space. Finally, the basis of our pyramid is constituted by physical space (real or virtual), simply conceived as "*the three-dimensional extent in which objects and events have relative position and direction*" [23]. The message here is that collaboration must happen in space and must use space as its most fundamental resource [24]. Why? First, because of the role which space plays in cognitive presence (see level 4 and level 5). At the beginning of his theory of mental activity, Kant explains: "*Space is a necessary a priori mental construct, which underlies all outer perceptions (Anschauungen)*" [25:38] and knowing, he adds later on, always requires a combination of perception and conception (ibid. B 74). Thus, space will be contained in any knowledge item and consequently also in any human thought. Second, because space plays an essential role in social presence. Recently Kim et al. [26] emphasized the importance of the affordance for pointing (the gesture specifying a direction from a person's body and connecting it with a distant item) when collaborating in a shared space. Expressing emotions, open communication and group cohesion are three components of social presence which are tightly related to space in the sense of "what connects and separates" [27] the persons involved. This means that space is essential as medium which enables social presence. Last but not least, collaboration must happen in space because space plays a role in leading presence. The leader of a meeting has to determine how participants will interact in space so that both

cognitive and social presence will be suitably supported and the work will be accomplished effectively and efficiently.

5 The Process of Collaboration

The Joint Knowledge Base (JKB) presented in section 3 and the Pyramid of New Collaboration presented in section 4 are tightly related and together enable us to explain some essential internal aspects of the process of collaboration. A knowledge base is built and maintained by several activities connected in closed loops (control loops): 1) introducing new elements (through assimilation or accommodation); 2) modifying existing elements when divergence arises during collaboration; 3) detecting divergence by monitoring ongoing interpretations of knowledge elements and comparing them with the intended interpretations for determining whether these fit; 4) last but not least, rectifying intended interpretations when there are conflicts (meanings do not fit). Each collaborator builds and maintains his/her own knowledge base so that, in a group, we have as many knowledge bases involved as there are collaborators. But the overall shared goal of working with the other collaborators on the same shared task leads within the individual knowledge bases to the emergence of areas which mutually converge (and resonate). In these convergent areas, meanings do not necessarily overlap or match across all the individual knowledge bases and we should more properly speak of *taken-as-shared* rather than shared meanings. We agree with Stahl [28:342] that group cognition is not "a simple sum of the individual cognitive acts of its members": in fact, this would be a very poor way of looking at the process. We instead need a much richer way, a systemic approach in which group cognition is seen as a system composed of individual cognitive acts of 2 kinds: elements and connections of the system. The notion of a *taken-as-shared* meaning [29] is consistent with a systemic approach; it implies that individual meanings fit for the purposes at hand and does not require that they match [29:166]. It is in this sense that we speak of a "joint" knowledge base: the JKB is the collection of those knowledge elements which constitute a unity because their meanings converge and fit across group activities and enable meaningful conversation in relation to the purposes which emerge step by step during collaboration on a shared task.

6. Analyzing Implementations: 2D & 3D platforms

One way of using the Pyramid Principle consists of applying it to the analysis and design of environments supporting collaboration. Below, we will analyse and compare two types of platforms for synchronous digital collaboration, a 2D platform like, for instance, Adobe Connect [30] and a 3D platform like, for instance, QUBE [31].When it comes to comparing the two collaboration platforms, we use the seven levels of our pyramid as categories and try to understand how well the platforms implement the features of each level (see Table 1).

In a 2D platform, New Collaboration suffers great limitations at each level and can hardly be said to take place. Level 1, the physical space, is not supported. This means that the main foundation of collaboration is missing! We need to take this seriously. This has negative consequences at all the upper levels on which collaboration is based. Specifically, it means that at level 2, social presence and leading presence are weakened and cannot work properly, especially when the activity requires collaborators to work in breakout groups. The next problem appears at level 3 where practically no artefacts-mediated interaction is supported, except for writing in a chat area or whiteboard area of the main window which is difficult to follow, organise and use productively. Thus, it is not surprising that the interactions are limited to the exchanging of information (level 4) with reification limited to showing slides or other uploaded documents and participation limited to talking (level 5). This leads to a very limited Joint Knowledge Base (level 6) and finally at the top, to collaboration activities limited to *talking* about tasks but not really able to *accomplish* collaborative tasks (level 7).

In a 3D platform, New Collaboration happens quite naturally like in a real physical environment at all levels. Level 1, the physical space, is supported by a 3D environment which simulates rooms and other places and provides avatars with which each collaborator can move around in the rooms, meet other collaborators, sit with them and chat at tables, visit panels, point to items on the walls of the room, walk to other rooms, work at an individual desk, etc. Social presence and leading presence benefit greatly from the ease of orientation, movement and connection which physical space provides; people quickly have a feeling of "immersion" in the environment, a feeling of "being there", without loss or split of identity [32]. As a consequence, breakout groups function very well, like in a real environment, perhaps even better.

	2D platform	**3D platform**
Collaboration	*Talking* about tasks	*Accomplishing* a collaborative task
Knowledge Sharing Joint Knowledge Base	limited to language	includes language, physical action and combinations of words and actions
Negotiation of Meaning	Participation limited to talking Reification limited to showing	Full range of participation and reification
Co-Construction of Knowledge	Focused on the exchange of information	Wide range of activities: co-creation, co-planning, co-solving, co-writing
Artefacts-Mediated Interaction	Not supported, except for writing in a chat window, which is difficult to organize.	Collaborators, through their avatar, can write cards, place them on panels, talk by pointing to cards, move from one panel to another one, etc. They can sit at a desk with a computer screen and write a document collaboratively.
Social Presence & Leading Presence	Breakout groups are difficult to lead; social presence is weakened by identity splitting: one person here (at my desk) and one there (in the Adobe window). Moreover, group members feel disconnected, lost and separated.	In breakout groups, leading presence and social presence function like in a real environment, perhaps even better. Easy orientation and connection among avatars. No splitting thanks to the identification with the avatar.
Physical Space	Not supported	3D environment where avatars can move, act, talk, sit at tables, write notes, walk to other rooms, etc. like in a real office or building.

Table 1: Comparison of collaboration in a 2D and a 3D platform.

A well-known example of a 2D platform is Adobe Connect, a web conferencing software which is described as providing "virtual rooms" and "breakout rooms" [30] although this is misleading because the "rooms" are not 3D, they are flat like a word processing window! So it would be more precise and more honest to use the term "window". Collaborators can use audio and video, share screen, write in a chat window or on whiteboards and record the meeting. But coordination is awkward and immersion and social presence are very weak, etc.; as a consequence, the foundations on which collaboration needs to be based are weak or missing. In summary: 2D platforms like Adobe Connect are far from sufficiently implementing the Pyramid Principle. A suitable example of a 3D platform is QUBE, a 3D collaborative virtual environment (3D CVE) of the type "virtual world", in practice a virtual "business building" (with many office rooms) which facilitates very immersive real-time activities. Three main features distinguish a virtual world from other CVE: avatars, configurable environment and user-generated content [33:30-ff]:

1. *Avatars*: each participant in QUBE is represented by an avatar, simple "lego-like" figures which work best, providing enough of a human form to enable identification but avoiding the distractions of more realistic forms. Collaborators can move their avatar around the workspace using simple keyboard and mouse controls; groups of avatars can form and disband as tasks require; breakout rooms can be easily accessed by walking into them and provide privacy or more security.
2. *Configurable environment*: a meeting room can be modified in advance before the first meeting and will remain available in future. Pin boards, tables and chairs, panels and other objects needed during the meeting can be placed anywhere on

the floor or fixed on the walls.

3. *User-generated content*: collaborators in QUBE generate content supported by tools called PETs (Performance Enhancing Tools) which consist of guidelines or procedures about how to accomplish a task which are printed on a poster; these posters can easily be replicated on any whiteboard or panel in the room. Thus, each PET interaction is, in fact, an excellent demonstration of an artefact-mediated interaction. An example of a PET is the previously mentioned "Hopes & Fears" guideline (see Fig. 4), a way to gather concrete hopes and concerns from the group at the beginning of a meeting. In summary: the Pyramid Principle explains very well why and how 3D platforms like QUBE can make online collaboration effective and efficient.

7 Conclusions

Collaboration seems to be easy, but it is not! The Pyramid Principle developed in this paper can help to take the complexity of the process of collaboration seriously, to understand its inner workings and on this basis, to devise ways and tools for better exploiting the potential of digital, online collaboration so that it becomes engaging, inclusive, empowering and performing. First of all, collaboration requires that collaborators continually attempt to construct and maintain a Joint Knowledge Base (JKB), an emergent taken-as-shared knowledge structure as a basis for accomplishing the shared task. Secondly, since the knowledge elements of the JKB must be socially negotiated, constructing the JKB requires engagement in a process of negotiation of meaning, constituted by two highly interwoven activities: participation and reification. Participation must be about something and reification must be of something: knowledge. The extent to which collaborators succeed in negotiating meaning and co-constructing knowledge, the so-called cognitive presence, can be increased if collaborators do not simply talk (language), they also need to engage in some physical action and interaction (combination of words and actions), a requirement that can easily be implemented by means of some artefact-mediated interaction, like the Metaplan technique. But the artefact itself is just an opportunity, a boundary object [21]. Making the most of it requires two types of resources and activities: social presence and leading presence. Finally, since physical space plays an essential role in enabling cognitive, social and leading presence, the foundation of the whole pyramid of collaboration is constituted by physical space. For delivering successful results in the VUCA world, New Collaboration must happen in space (real or virtual) and must make use of space as its most fundamental resource.

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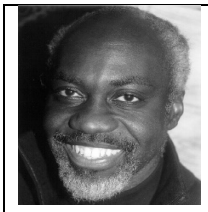

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