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3D BOUNDARY OBJECTS IN STAKEHOLDER MANAGEMENT: KNOWLEDGE CREATORS

for the project and collaboration facilitators

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ABSTRACT

The study presented in this paper deals with the use of 3D boundary objects in stakeholder management. The main research objective is to understand the contribution that 3D boundary objects can make to a project in terms of knowledge and stakeholder engagement. The methodology used here is of a participatory and collaborative nature, and this choice is tied to the praxeological and theoretical context of the study. The results of the study show that 3D boundary objects facilitate the engagement of stakeholders and create knowledge in certain conditions, in particular related to the management style of the project manager, his or her experience and expertise. The praxeological and theoretical implications encompass both learning for a practitioner and the pertinence of enriching certain project management conceptualizations.

1. Research context

Stakeholder management is not in itself a new topic in the field of management. Strategic management has been addressing the subject for a number of decades. We need only think of the sociologists Cyert and March who wrote A Behavioral Theory of the Firm in 1963 and of Freeman's prominent works, including A Stakeholder Approach, published in 1984.

However, in the field of project management, stakeholder management is a much newer focus of concern and research. The last studies to delve precisely into stakeholders and their management in the context of a project date back to the 1990s. Pinto *(2002)* and Karlsen *(2002)* are among the first researchers to address these components of project environments and to suggest methods for the establishment of pertinent stakeholder management. While Pinto *(2002)* sees it as falling within risk management, Karlsen *(2002)* suggests the use of communication as a control tool.

More recently, many project management specialists and researchers have focused on stakeholders *(Bourne, 2009, Jepsen and Eskerod, 2012, PMI, 2014)* given the growing complexity of projects *(Roy and Vernerey, 2010)* and the "new" problem of project social acceptance or acceptability *(Wüstenhagen et al., 2007, Caron-Malenfant and Conraud, 2009)*. Certainly, complex project development entails increasingly close stakeholder management for the launching of "acceptable" projects. But it should also be noted that a project's social non acceptance has a price, as it can engender cost, delay, redesign, and even the cancellation of the project.

The notion of social acceptance or acceptability can be defined as "the acceptance or not by the stakeholders in a given project of the project's emergence, continuation, realization or implantation" *(Wolsink, 2010)*, or, following Caron-Malenfant *(2009)*, as "the result of a process, by which the concerned parties build together the minimal conditions to put in place in order to enable a project's harmonious integration at a given time in its natural and human environment."* *(These and ensuing translations are our own.)* The notion of complex or major projects here refers to the works of Remington and Pollack *(2010)*, as well as the original research on large-scale projects produced by Declerck, Debourse and Deckerck *(1997)*, for whom a complex project necessitates large-scale financial investment; is carried out over many years; involves multiple stakeholders of diverse backgrounds; and whose construction combines various approaches.

In fact, collaborative approaches in project management have become a "hot topic." From an empirical point of view, many changes have occurred in the area of large-scale, and in particular urban, projects. In the general context of a worldwide urban explosion expected by 2050 *(Bouton et al., 2003, Baron, 2013)*, with an increasing desire on the part of citizens to participate in the projects of their cities of the future *(Haouès-Jouve, 2013, Ladet, 2012)*, numerous metropolises have already changed their approach to carrying out large-scale projects. Barcelona, Amsterdam, and New York are well known examples in this respect *(Dorval, 2014)*, where stakeholder management is carefully considered with a view to shared performance.

In the hope that at least some of the large-scale urban projects imagined by architects, urban planners, engineers, technicians, governments and private developers will materialize in one form or another, new practices of large-scale project co-building are being established. They place stakeholders, including users, at the heart of the project's definition process. Some projects are even drawn up by stakeholders, as is the case for a few eco-neighbourhoods, while specialists and project management experts provide support *(Viel et al., 2012)*.

Places of "knowledge-brewing," bringing together large numbers of diverse stakeholders, are emerging in various places *(Girard, 2013, Dubé et al., 2010)*. Citizens, civil society representatives, local elected officials, leaders of lobby groups, retailers, community association representatives, architects, urban planners, anthropologists, political scientists, management and project management researchers, and consultants, among others, participate in these activities, where knowledge, intended for the building of a socially shared and accepted urban life project, is recombined.

Public and private organizations mobilize various tools in the co-building of large-scale projects, from working tables lasting just a few hours to meetings stretching for days and comprising several stages. They generally use communications firms, social development associations and teams of specialized consultants, many of whose facilitators are also researchers. Stakeholder information- exchange mechanisms – often of a small scale –geared toward project co-building, include consultation series with stakeholders, round tables for dialogue, Future Search workshops, practice communities, collaborative virtual simulation, and physics simulations in "serious games" *(Prahalad and Ramaswamy, 2013)*.

Globally, in the area of the "more" modern large-scale project development mechanisms, those based on dialogue *(Beaudet, Meloche and Scherrer, 2012)* seem to prevail, although the notion of dialogue is "understood" and "applied" in varying ways. In this regard, a few years ago, the City of Greater Lyon published a documented methodological guide, accessible to the public, entitled "Dialogue in project management" *(La concertation dans la conduite de projet)*. More recently, in May 2014, a seminar organized by the Deciding Together *(Décider Ensemble)* association was held in France on the topic of "Industrial projects: What place is there for dialogue?" *(Projets industriels: quelle place pour la concertation?)*, which brought together over thirty researchers and practitioners. In 2015, the Minister of the Economy, Emmanuel Macron, tabled a draft bill geared toward facilitating projects. Section 28 of the bill deals with the participation of the public, in issues relating to the environment *(spatial and urban planning, etc.)*. The purpose is to "modernize and clarify the procedures for public participation, dialogue, consultation and information." Other types of initiatives have also been launched.

Aside from this dialogue mechanism, there are others based on the principle of open innovation or co-innovation *(Chesbrough, 2003)*. These new mechanisms, such as Livings Labs, allow for more active stakeholder participation, especially of users, in the development of urban products and services that directly affect them. With co-innovation approaches, users truly become project co-developers to the same extent that knowledgeable experts in engineering and project management, for instance, are, or even more so. Considered as use experts *(Léger, 2012)*, they intervene throughout the process, and not only in the conception phase, to enable the project to materialize. So far the use of these mechanisms remains limited, but the large number of initiatives testifies to their growth, and the increase in LLs is indeed noticeable *(ENOLL)*.

In the case of large-scale engineering projects, a number of project managers have followed these trends, or have

been ahead of the curve, and have developed new operational approaches to stakeholder management. They all aim to foster interactiveness with partners and the ability to develop projects "serenely" and to see them through.

More or less collaborative *(of the consultative, dialogue or co-innovation type)*, these management approaches borrow from augmented reality, 4D geomatics, and from objects derived from 3D printers. Thus when a large-scale project, such as a dam, is launched, Hydro-Québec, for example, uses 4D geomatics, among other means, to share problems, difficulties and questions with its interlocutors, be they service providers, sub-contractors, local communities, engineers, or operational managers *(PMI symposium, 2013)*. According to Ubisof Inc., one of the advantages of using augmented reality is the ability to define the stakeholders' shared challenges in a given project *(EJC, 2013)*. Although a number of works bring to light these "new" practices, up until now few scientific studies have presented field research exploring novel practices using these new tools made possible by the advent of ICT.

The issues of sharing, transfer and creation of knowledge, in particular, have been studied very little, although the use of boundary tools and objects in project management *(Star and Griesemer, 1989, Bowker et al., 1999)* refers directly to the question of acquired and useful knowledge for projects *(Lehmann et al., 2014)*.

2. Research objectives and methodology

We have therefore sought to examine the following: What is the contribution of 3D boundary objects to a project? How are boundary objects used in the field to manage stakeholders? Why do boundary objects "speak" to stakeholders? In what kind of project contexts do they become so evocative? How do they contribute to knowledge construction that is relevant to the project?

These questions have led to research designed to better understand what 3D boundary objects can contribute to a project in terms of relevant knowledge and stakeholder engagement. This study deals more specifically with the use of 3D objects in complex projects *(Remington and Pollack, 2007)* entailing stakeholder collaboration.

The scope of this specific study is limited to one type of boundary object used in action, namely concrete objects, derived from 3D printers. They are original and unique. They will be presented a little further in the text.

The methodology used to answer the research questions is exploratory and to a large extent, refers to the "grounded" approaches. Our scientific positioning adopts participative or partner research *(Fontan and René, 2014)*, a method that is close to the Participative Action Research approach *(McIntyre, 2008)*, where the studied persons *(and objects)* are considered to be active participants in the research and can be involved as researchers. The study is also a monograph for the parts that consist in a historical overview and the practitioners' histories.

Considering the exploratory qualitative nature of the study, there is no formal conceptual framework to apply for the purposes of collection and analysis. However, the research was guided by specific concepts and elements borrowed from the project management and knowledge management literature that we deemed relevant. Based on the principle of partner and participatory research, the researcher and the practitioner jointly chose the guiding concepts for the field study. These concepts, as well as a review of the pertinent literature, are presented in the chapter following the methodology.

The methodological orientation adopted here led to a longitudinal study of the use of physical type 3D objects by project directors and a number of project managers from a single organization in the context of their work with stakeholders in large-scale road infrastructure projects. The study was conducted through meetings with the practitioner-expert-researcher and note-taking during interviews and observation.

We followed a number of large-scale civil engineering, infrastructure and spatial planning projects. Field observation focused first on the use of 3D objects, as well as on how different users in the context differ depending on the project and the stakeholders concerned. These practices are illustrated by accounts presented further on.

The two 3D objects that are the focus of this research were designed by the project director and custom-designed by a designer. They are original and unique in several respects. On the one hand, they are the result of research and of a unique personal and professional history. On the other, they were designed for specific, although several and distinct, projects. Finally, they are the property of their creator and his organization. These two objects are Aladin's Cube and the Tessera Area.

Aladin's Cube, (3 cm x 3 cm x 3 cm), described by the practitioner

Figure 1

"I found reading Douglas Hofstadter's book as a student quite startling¨, described the practitioner-researcher. ¨The cover of the book depicts a cube sculpted out of the initials G E B for Gödel, Escher, and Bach *(***Figure 1***)*. The book describes the connections between Gödel's mathematics, Escher's art and Bach's music. It demonstrates the "sprigs of an eternal garland," revealing the unity of the essential structure of the world that lies beneath multiple facets. My childhood memories came rushing back, with great intensity, in one fell swoop: Sundays at my grandfather's, adults' conversations, and the stories that came from "my" cubes… The idea of the "letter cube" came naturally to me several years later as a means of designing and printing my first object. From the start, I chose to interlink four very visible letters: E, C, and two Rs.

My intention was to examine a new process for meeting with project stakeholders: the State, local authorities and nearby residents. The letter E stands for "État" in French, meaning State or central government; the letter C stands for "collectivités," meaning local communities; and the two letters R, stand for "riverains réunis," meaning nearby reunited residents *(see further)*. I wanted to reveal, tell and give meaning to my projects. Putting these four letters in a cube pointed to another letter, not as obvious, yet present, the letter M: multiple, multi-faceted, multi-interlocutor, malice, and magic… The choice of the letters E, C, R and R, completed by the fortuitous appearance of the letter M, in French constitutes a moderate lexical constraint, neither strong, nor weak. In fact, the letters E, C, R and M start 24,625 words out of the total 78,855 words that the 2007 edition of the Petit Larousse illusté dictionary contains. By offering the possibility to use 30 percent of common vocabulary, they require some thought, while allowing for a range of expression that is sufficiently wide in order to be effective. In addition, when looked at from a different angle, the M, could be used as a W, and the C, as a U. Unlike the five other sides, the sixth side of the cube remained indecipherable. Ultimately, this illegibility is logical: it represents the hidden side of the project, what has remained unspoken, overlooked issues that emerge unexpectedly, and stakeholders that weren't identified at the start. In the middle of the six sides, there is an empty space. Void or essence? For the stakeholders the project is focal: State, local communities and nearby residents reunited. In the middle, an empty space where what is invisible and immaterial contains the essential: it is the meaning of the project, the space where individual histories intermingle in a common story to give rise to a shared and consensual dream."

"Projects for roads, tunnels, trains, stadiums… Aladin's Cubes have been used in many cases with various interlocutors.

An Aladin's Cube enables a project manager to show each stakeholder that the latter's individual point of view is clearly seen and that the stakeholder's own responsibility is to take them all into consideration for the project's development. With a concern for orienting each side of the project to the concerned stakeholder, the cube helps the project manager make mutual expectations more comprehensible.

That said, the cube is designed in such a way as to be used by all stakeholders in turn or as needed, in a given situation. At the end of each meeting, a cube is offered to each interlocutor. From a simple piece of plastic, it can turn into a battery charged with the emotions exchanged, and since it is kept, it should help perpetuate the bond that has been created regardless of physical distance and time.

In the exchange with stakeholders, the sides E, C and R represent the diversity of categories, including :

- The protean State: central government, Prefect, regional and local authority offices and services
- Multiscalar local communities: tiny municipalities with a population of around 100, big cities, urban centres, counties, regions. Each has its own vision for the project, varying according to its distance from the project's location, its political sensitivity, its sister alliances, etc.
- Nearby residents: individuals who may act alone, form local associations, or join national associations. Perceptions vary: for or against the project, with different sensitivities (environmental, ecological, economic, political, etc.)

The "indecipherable" side represents an issue that may have been neglected and, despite excellent project preparation, may emerge brutally and call into question the history written so far. For example, the discovery of a protected beetle species, commonly known as the "hermit beetle," put the construction of a section of the A28 highway between Le Mans and Tour off for five years.

The Tessera Area (6 cm x 6 cm x 1.5 cm), described by the practitioner

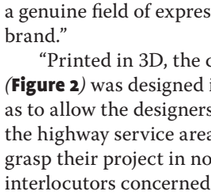


Figure 2

"In ancient times, the Tessera *(a Latin term)* was an object *(***Figure 2***)* used as a distinguishing mark by the members of a community to identify themselves", said the practitioner-researcher. "Sometimes the gift of a Tessera was accompanied by a narrative, also destined for dissemination within the group.

The 3D Tessera is a metaphor for the concept of a service area of the kind that we would like to offer a clientele of highway users on their way to a destination. It must be noted that highways in France are dotted with service areas, including gas stations. In the French highway model, the highway operating company issues a call for tenders and the chosen bidder normally manages the entire service area on its own behalf. Bidders are important oil companies, with a brand and an image attracting substantial investments. The project in question here is the "creation" of service areas in accordance with a set vision of servicing customers, while leaving a genuine field of expression for the oil brand."

"Printed in 3D, the concept object *(***Figure 2***)* was designed in such a way as to allow the designers consulted on the highway service area conception to grasp their project in novel ways. The interlocutors concerned have broad experience in the field of service area design, and my wish is to make them work differently, especially by encouraging them to go beyond the usual mental pattern of their trade in order to grasp our real needs from new angles and to understand us better. This original way of proceeding forces the contractor to simplify the operational concept

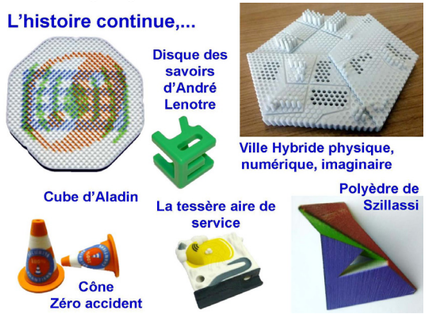
in order to preserve only the essential, i.e. "the spirit" of the project that is hidden in the 600-page specifications drafted by lawyers.

First, I added a "dream journal" to the project specifications in order to embody the service area program through the drawing and the object. The results were, however, unsatisfactory. I therefore had a 3D object made to embody the program concept published along with the tendering documents. The bidding designers must make an offer that complies with the concept expressed through the object. This boundary object gives shape to a new service area concept. Six months of team work were necessary for the concept and the object to come together."

The Tessera, a service area model, is an object to be used by two people simultaneously. As they handle it, players learn to use it individually and collectively. It was conceived to foster verbalization and dialogue among stakeholders. Offered to individuals who have tried it, the Tessera should continue to solicit both discussion and imagination. Its force is amplified when used with the following script.

Other 3D objects used

For the purposes of information and transparency, we stress the fact that the two 3D objects studied are part of a "set" of existing 3D objects. Presented below, they demonstrate the range of objects and projects, as well as the practitioner's ongoing commitment to this approach.



3. Concepts and relevant literature applied

The relevant literature for this research lies at the crossroads of several disciplines: project management, knowledge management, sociology of uses, and innovation management. In the introduction, we mentioned that our research is conducted in the areas of sociology of uses and innovation. We shall now address the field of knowledge and project management. The literature in these fields pertaining to our research is presented below.

Most works in the area of project management that correspond to "inclusive" project management, promoting the involvement of stakeholders at the onset of the project, stem from research on large-scale IT/IS projects. These works refer to agile approaches that take into consideration "user stories" at the time of the project's conception and engage the client as a partner *(Messager-Rota, 2007, Boisvert and Trudel, 2011)*. These agile methodologies also encourage grasping the project as "do-it-yourself" and welcome "negotiated" changes along the way *(agilemanifesto.org)*.

The concept of "creative negotiation," so dear to Midler *(1996)*, and that of "meta-rules" put forward by Navarre *(2008)*, also suitably express the need to involve stakeholders in the project process. Karlsen's conclusions, drawn in 2002 on stakeholder management, already emphasized the importance of responding to their expectations for the project's success. Jepsen and Askerod *(2009)* underscore the necessity for stakeholders to be at the table in any project.

A number of other project management studies, such as Murtoaro and Kujala *(2007)*, according to whom a project is a long "chain of negotiations" among players, are also consistent with the idea that stakeholders are also partners in the project.

It is interesting to note that in political science *(Lamizet, 2013)* and in urban planning *(Beaudet et al., 2012)*, so-called inclusive management approaches have been studied for decades. Issues of self-developed habitat gave rise to a number of theoretical debates from the 1960s until the 1980s, around the idea of collective design of housing projects *(Revedin, 2014)*.

From the project management literature, it can be concluded that the advantage of involving stakeholders in the project's process is an established fact, even though some authors see it as a constraint, while others consider it to be an opportunity.

With respect to knowledge management literature, it is imperative to mention Trépos's work *(1997)* on distributed knowledge. Trepos asserts that knowledge is not limited to a few individuals. In his view, knowledge is widely distributed; each person possesses knowledge on something. Thus the user has solid knowledge of uses *(of a product, a service, a bridge, a road, etc.)*. As such, he or she can be regarded as an expert on this product, bridge, etc., an opinion shared by Léger as well *(2012)*. In 2002, Nowotny, Scott and Gibbons added that knowledge is "socially" distributed and is passed on through networks of actors.

Regarding the "common" knowledge of users, Frangioni *(2012)* highlights that Von Hippel's studies *(1986)* already portrayed users as carriers of knowledge for innovation development, although "lead-users" are not "co-developers," "for they only take a position on the improvement of an already designed and developed product, which is presented to them as a prototype to be improved. They do not act as designers in the ideation and creation phases of a project, but rather as testers in the operational prototype phases." Frangioni adds, "Only with Prahalad and Ramaswamy *(2004)* was the user-driven innovation approach developed." The work of Chen et al. *(2010)* confirmed that users are essential to innovation projects.

Furthermore, several contemporary scientific works demonstrate the effective contribution that stakeholder knowledge makes to projects, in particular user knowledge. The research conducted by Le Masson, Weil and Hatchuel *(2014)* deals with the C-K theory, in which users represent input in the project. A study by Lehmann et al. *(2015)* also highlights the extent to which knowledge created within Living Labs is useful in projects. Unlike the C-K theory, the latter is not an analysis of a conceptual approach, but rather of an approach to project co-creation, follow-up and implementation.

In order to convey what knowledge means in the context of this study, the concept should be clarified. We adhere to Legendre's view of knowledge, as deriving from "facts, information, notions, principles acquired through study, observation or experience," while positing at the same time that knowledge also results from interpretation and is therefore not entirely "external" to the individual. The notion of knowledge that we have adopted is the following: a "set of extended knowledge acquired by an individual, through study and experience" *(Legendre, 2005)* and also through "absorption, imitation, concrete experience, guidance of elders, demonstration, trial and error, and exercise" *(Ermine, Guittard, Lièvre and Paraponaris, 2012)*. In addition, the "knowledge" referred to here is clearly at the same time the "product of an activity, a context and the culture in which it is acquired and used" *(Brown, Collins and Duguid, 1989)*.

In fact, it is "knowing" more than "knowledge" *(Argyris1995)*, knowledge in action or actionable knowledge, that is the focus of our investigation, rather than knowledge that is held, yet not expressed.

In consequence, the concepts used to grasp the role of 3D boundary objects *(Lee, 2009)* that participate in the creation of knowledge in action are those of "learning in organizing" *(Gerardhi, 2006)*. Finally, we also call upon the concepts of experiential knowledge and referential knowledge *(Lièvre and Rix-Lièvre (2012)*, as well as ambidexterity *(Lièvre and Aubry, 2010)* focusing on knowledge exploitation versus knowledge exploration.

The most important element to draw from this crossing of the field of knowledge management is that a number of studies demonstrate that stakeholders hold knowledge, and "common knowledge" can be as relevant in certain situations as what is known by knowledgeable experts.

4. Results, learning and interpretation

Connected to the research questions established above, the partial results obtained so far indicate that the specific use of 3D boundary objects allows for an increase in stakeholder commitment and facilitates knowledge creation that is relevant to the projects concerned.

It appears in fact that a 3D boundary object helps reveal the knowledge that is present, and that in a "specific" situation, from an intensive handling of the object, emerges useful knowledge. Depending on the interlocutors and the project, knowledge is sometimes technical, sometimes social or local. In the case of Aladin's Cube, when engaging stakeholders with letters rather than words, the design seems to stimulate the expression of ideas and comments related to a new project or a project already underway.

Our observations, notes and interviews with experts show that stakeholders faced with a 3D object, on the one hand, will do something with it, and on the other, in the management context that rules the use of 3D objects, what they do with it helps make the project succeed, since an "animated" handling of the 3D object increases stakeholder satisfaction.

It is quite obvious that in most situations, each interlocutor *(confronted with the project director)* appropriates the object and projects his or her own history, thoughts and emotions on it: "When I was little I had cubes too," "have you thought of the way...," "in my opinion...," are among the expressions uttered spontaneously while handling the cube. Following a short period of getting used to the object, the interlocutor and the original holder of the cube start to express unspoken ideas by way of association. The empty space in the middle of the cube in particular evokes conversations relating to a hypothetical hidden side of the project. It is likely that the interlocutor will make comments and express ideas that he or she may not have wanted to address had the cube not been present.

In a group setting, handling the object enables verbalization revealing the diversity of viewpoints and exchanges relating to the project within a perspective of proposing solutions. Aladin's Cube undoubtedly makes it possible to see beyond the usual appearances and to delve deeper into some aspects of the project.

The following example of the use of Aladin's Cube is an illustration of this result:

The meeting was called because the layout of one of the highway projects was affecting the territory of a middle-sized municipality. At that first meeting, the mayor expressed "distrust" as he welcomed the director of the project. The project director (PD) placed a cube on the table in front of them. The mayor stepped back is if to avoid being burned. The director then asked him to take it. Intrigued, the mayor picked up the cube and examined it thoroughly. The PD then spoke of his childhood, Aladin's lamp, and so

on. The mayor gradually got used to it and started telling his story. Placed in the context of the project, it helped him situate himself; to the C (local community), he answered "mayor." When the PD continued with the other sides, the mayor completed the sentences, flipped the cube, examined it from every angle, and expressed his fears and questions. The PD listened and talked about the project. The mayor responded. Before parting, they drafted a summary of their meeting. The climate had changed, and words seemed to reveal a mutual understanding. Trust appeared to be taking root. Six months later, when the PD walked into the mayor's office for a new meeting, the mayor welcomed him warmly, picked up the cube that was sitting next to his telephone and proudly said: "You know, since you came, this cube has heard all sorts of stories! I even used it at home to plan our vacation. That's right; I wanted to tell you...." Once the project was underway, relationships seemed to remain cordial.

From the practitioner/project director's standpoint – both expert and researcher in the context of this study – other results should be reported:

"With the help of Aladin's Cube, in a quarter of an hour, it is possible to explain to the technician who comes for a soil survey that access to the site requires the farmer's authorization, and that the farmer can't be seen as an annoyance, because from his point of view as a nearby resident, the technician is the intruder. Thus each person grasps stakeholders in a different light, even if it is a 15 million-work-hour project.

After having held meetings without Aladin's Cube for the purposes of comparison with other media types, such as lists, words and images, I came to the conclusion that a flat, two-dimensional description does not have the same force as a 3D object. Through touch, the object printed in 3D can enable concrete multiscalar permanent interactions. It enriches the cognitive experience and widens the scope of potential mutual comprehension. In addition, although at first glance the letters may seem ill adapted to intercultural exchange, I have witnessed Aladin's Cube working very well for Anglo-Saxons and Japanese. A Japanese person even added an audio dimension to the experience by hitting two cubes together, making them resonate.

Certainly the results cited regarding the creation of knowledge that is relevant to the project should be juxtaposed with some studies on co-innovation and knowledge management that we cited in the introduction, and others as well. When Chesbrough *(2004)* says that co-innovation is a "profitable" approach, he means that the knowledge held by stakeholders *(including users, service providers and subcontractors)* about a product or a service can have input in innovation. The C-K theory proposed by Le Masson, Weil and Hatchuel *(2014)* stresses the advantage of picking up the knowledge *(K)* held by certain stakeholders for the development of a product, a process or a service. Regenerated through new knowledge, the K space is considered as a set of decidable propositions, thus giving the K operational status for a project. Existing knowledge and knowledge created through exchanges among players is "profitable" for the project.

The results showing that stakeholder involvement increases thanks to the 3D boundary object are congruent with the view of "boundary objects" promoted by Wenger *(2000)*. He sees several aspects in boundary objects *(concrete or abstract)* that arouse interest: the boundary object applies to various practices and activities; it facilitates dialogue; several of its sides can serve as a basis for dialogue among players; and it makes the information interpretable by these players. As early as 1989, Star and Griesemer stated that a "boundary object," which by its very essence cannot but be social, strengthened cooperation among players and enabled various players to pull together.

Our own results suggesting that 3D boundary object increase stakeholder engagement can also be placed in relation with the contribution in terms of meaning of such experiences and what they entail. Weick *(1995)* affirmed that "sense making" fostered "commitment." In addition, Kumar and Singhai's work *(2012)* shows how sense making allows individuals to adopt change or a project for change. Piaget had already specified in 1972 that "to understand is to invent."

Among the results obtained in relation to the above-stated research questions, we should note that certain management approaches and conditions of use facilitate the creation of knowledge that can be mobilized in action or is actionable.

In this respect, we believe that the type of management and expertise that the project manager applies in his or her domain constitutes determining conditions for an "intelligent" or "relevant" use of 3D objects with stakeholders.

We were able to observe that the two 3D objects called upon here, namely Aladin's Cube and the Tessera Area, do not present an equal interest for stakeholders, depending on who holds the object and how it is introduced. Even though use clearly varies from one holder to another and communication mechanisms cannot be completely reproduced, the fact that the project manager knows his or her project and considers stakeholders a priori as contributing resources apparently helps make the 3D object a vehicle for knowledge creation and for stakeholder engagement.

The results of our study appear to indicate therefore that the boundary object fully plays its role as a facilitator of collaboration and a knowledge creator given a "conscious" project manager, in the sense provided by Akerman-Anderson and Akerman *(2004)*. With a manager who is conscious of the limits of his or her competency and who seeks to learn alone and from others, it is reasonable to believe that stakeholders can contribute and that knowledge creation can be a desired objective.

Results regarding the fact that certain conditions are necessary in order for the boundary object to significantly contribute support the findings of Picq *(2011)*, who maintains that project managers who are able to impress the meaning of their project upon members of their team will succeed in creating cohesion and good team performance. They also support Bellenger's suggestion *(2008)* that the project manager's role is a delicate exercise in people management, requiring boldness and caution.

5. Implications

Although a confirmation of the results obtained requires that this qualitative study be extended, including a quantitative development, this research already has a number of theoretical and praxeological implications.

Consequently, we believe that the account of the practitioner who participated in the research, presented below, provides a good summary of most of the praxeological implications tied to this research.

According to the practitioner/project director, the experiences with Aladin's Cube and the Tessera that he took care to examine during the study generate important learning in relation to the way he manages projects in various respects:

"Before using 3D objects, I felt powerless in the face of the increasing complexity of projects and their context. With the practice of 3D objects, I was gradually able to get a grip on the complexity through cooperation. I not only learned from it, but was also profoundly changed. Today this transformation is gradually being expanded.

Using the cube led to a break in my way of conducting projects. I went from a projection, demonstration and forceful persuasion mode to open listening and effectively integrating seemingly contradictory demands thanks to co-building. In my early career, I committed to applying the techniques commonly taught in communications in my meetings with stakeholders: I practiced listening, reformulation, explanation, and visual demonstration *(with pedagogical diagrams or synthetic imaging)*. I used the two senses most widely applied in this area: listening and sight. I therefore talked, listened and showed my interlocutors pretty images. With 3D objects, I added touch, and in terms of my managing of stakeholders, this proved to be transformative. With project managers, my work also changed. I am more open to debate; I cultivate the idea and like the fact that an issue must be seen from various angles. I have also understood and accepted that a project is not a unique and monolithic reality. It presents as many different aspects as the Cube or the Area can reveal, all equally true."

Concerning the learning that came with the use of Tessera, the practitioner noted: "The Tessera has enabled sustainable crystallization of the meaning and soul of the service area program throughout the years and as the individuals in charge of the project have come and gone. The Tessera also makes it possible to bring together transdisciplinary teams around a single project. In this regard, it constitutes a major change in the way people work and address the project's issues. Indeed, in the classical method of project management, players attempt to grasp the main needs through words, but the numerous interpretations that arise draw attention away from what is essential. Alone or in a group, the player always writes, trying to evoke the operational aspect of the concept to finally come up against the deadlock of the designer's free creativity: the latter, in fact, must comply with a locked description of specifications. When the project manager receives tenders, he or she is surprised to discover stereotypical soulless projects, lacking creativity and innovation. Conversely, the intermediary object described, which is anything but a physical representation, allows the project planned to be expressed in a firm manner while at the same time leaving room for the designer's imagination."

From a praxeological point of view, this study also shows that working collectively with boundary objects, which are presented here as simple objects coming from small 3D printers, can substantially contribute to the project's improvement, from the conception phase to implementation, and to seeing it through in good conditions. The study suggests that project management needs creativity in order to meet the challenges of complex projects, in particular when stakeholders perceive themselves as "experts," as several authors have already stressed, including Terrin *(2014)* in Le projet du projet *(The project of the project)*, who promotes participatory and collaborative projects and stresses the importance of building a shared vision of the project with stakeholders.

The theoretical implications in the area of project management relate to both stakeholder and project management. In this regard, by way of conclusion, we would suggest that the field of project management could draw more extensively from knowledge management in order to better grasp the implementation of current complex projects *(Alderman et al., 2005)*. Thus theoretical approaches of co-innovation and open innovation *(Chesbrough, 2004)* could be mobilized in order to study and discuss current project conception. Conducting research by mobilizing theoretical approaches to knowledge management relating to socially distributed knowledge *(Nowotny et al., 2002, Dubé et al., 2014)* would constitute an appropriate orientation to facilitate a better understanding of the successes and failures of current projects. Furthermore, we believe that the results of this study show that enriching the conceptualizations of stakeholder management as suggested by Freeman et al. *(2010)*, which are often oriented toward communication activities in the context of project management *(Girard, 2013)*, would be a welcome development.

Finally, from a methodological point of view, we firmly believe that considering the volume of cross-learning between the researcher and practitioners having resulted from this study, other project management researchers should undertake research using PAR-type and partnership approaches *(Fontan and René, 2014)*.

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