Building Information Modeling for Participatory Decision-making Processes

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This paper presents and discusses the partial results of ongoing research on the development of computer applications connected to Building Information Modeling (BIM) software, aiming at the participation of non-technical actors in decision-making processes for public facilities projects. The research proposes the construction of a web-based application in which remote collaboration between technicians and non-technicians can be carried out in architectural design processes. The article points to the relevance of such cooperation in newly industrialised countries, reviews the key features of BIM, and presents the application currently under development. The paper focuses the theoretical discussion and characterisation of relationships between the involved parties and the practical implications of these reflections on the structure and design of the application. This research work is underway at the research group Nomads.usp of the University of São Paulo (USP), Brazil, and expects to contribute to the formulation and implementation of public policies in the sectors involved.

Keywords: *BIM, Participation, Public facilities*

INTRODUCTION

Participatory design and community participation in the decision-making process received considerable attention from urban planners and architects in the 1960s. This enthusiasm quickly led to a sentiment that participation hardly influenced final architectural results. Most of the times, communitarian participation appeared to be just a seal of approval issued by the community, more often than not compelled to choose between design proposals not representing its desires.

However, the ideals of participation grounded the thinking of generations of urban planners and architects. Lucien Kroll, in the 1970s, developed his principles of participatory design framed in extensive debates with future users, constituting pioneering initiatives of the effort of sharing design decisions with the residents. To accomplish such collaboration, Kroll made widespread use of physical models, and computer programs from the 1980s on (Bateli, 2015). It is, however, of Christopher Alexander the most incisive contribution to the computerisation of design processes aimed at the inclusion of the inhabitants. His book "A pattern language", of 1968, became a significant reference in the area, mapping 250 patterns of human behaviour in the built environment,

in the manner of design and organisational parameters. The works of Kroll and Alexander were precursors to the introduction of algorithmic thinking in architecture, and helped to construct procedures that would later be useful in the design of current parametric programs, especially those based on BIM. Their work range undoubtedly among the main references of the research on participatory processes in architecture, albeit in a somewhat mechanised and impersonal way.

In order to broaden and deepen the results obtained in previous works of Nomads.usp, and dialoguing with studies by Harvey (2012), Castells (2012) and Manovich (2013), among others, this research understands that the use of digital media - especially those based on Internet communication - can configure spaces of citizenship, community articulation and claim for rights. Of course, these media do not replace the face-to-face debate on the public scene but, associated with it, can constitute a hybrid territory - of concreteness and virtuality (Tramontano, Santos, 2013) - where substantial portions of urban life are developed. Likewise, such media may contribute to collective reflections on the importance of ensuring the implementation of the decisions taken therein, broadening its scope and its catalytic and articulating role.

This condition is particularly critical in countries of recent industrialisation, such as Brazil, where public policies for urban development are still under construction, and impunity for corrupt actions involving politicians and companies in the construction sector contributes to reducing the limits of government investment in public works further. However this scenario is slowly changing, with the examples of good practices such as the Participatory Budgeting program (Souza, 2001), laws that mandate the municipalities to establish thematic councils including the organized civil society to access the federal's credit lines and the online digital platforms used by several prefectures around the world, of which Decide. Madrid (https:decide.madrid.es) is undoubtedly a valuable reference.

In this context, the recent initiatives in Brazil to enforce the use of BIM in all public construction plans (Brasil, 2018) present an opportunity to further public involvement at the same time that it can help foster a culture of transparency and meaningful conjoint decisions. To contribute to the active participation of the population, the research presented here aims to expand the collaborative uses of BIM software in public equipment design processes, through the optimisation of communication among its actors and the inclusion of portions of the population with a direct interest in their results. They are: the inhabitants and merchants of the urban area in which the public equipment will be located; its permanent employees - employees and end users - public service employees involved, cultural collectives and associations of the Third Sector, public managers, political and private sector representatives, as well as technical professionals such as architects, town planners and engineers. In order to do so, the research benefits from four fundamental properties of BIM: 1. the insertion and visualization of information from building to design in a unique three-dimensional digital model; 2. the stimulation of communication among the various actors, allowing mutual monitoring and learning, 3. the registration and representation of information relating to the building throughout its life cycle, ie from the initial design to the occupation, adaptation and demolition phases, and 4 the possibility, at all stages of the process building, budget control associated with constructive elements and services. This paper identifies these actors and their relationships, aiming at establishing the potentialities and parameters that can help with the construction of a platform of collaboration between technicians and non-technicians in through the production process of public facilities.

DISCUSSION

The lack of predictability and transparency in the use of public resources is a pressing discussion in Brazil, especially in public construction projects (Santos, 2015), which leads to an environment where cor-

ruption and misuse of public resources can thrive. International experience and the literature indicate that to address this situation, a profound change in the production process of the public facilities is necessary. This change involves more factors than the isolated adoption of new tools or design processes, such as BIM, or the passing of harsher legislation - it needs the adoption of a holistic approach to the question, and the involvement of the community at large in the day to day activities of the governments is an essential part of this strategy (De Sanctis, 2015).

We understand that BIM is suitable to operate as a platform for the operationalisation of these changes since it presupposes a collaborative process, in which the information about the design, execution, operation and maintenance of a building is integrated and simultaneously available, subverting the current sequential logic. In this collaborative and integrated environment par excellence, where information flows in multiple directions, one can not speak, on the one hand, of compartmentalized knowledge, as in a conventional production line; this interdependence, on the other hand, generates the need for the rearrangement of the entire productive structure, since it also involves a shared responsibility. The impact of this platform is therefore more significant than just compliance with new rules and processes; it involves universes beyond the technical domain of Architecture and Engineering, interfering, as already said, in the economical, political and social spheres. This is statement is supported by several studies, such as Succar (2009), Sacks (2010), Linderoth (2010), Pentillä (2006), among others.

The Brazilian government's recent initiative to implement BIM (Brazil, 2017) as a federal public policy is important because, as policy maker and one of the main contractors of the field, it helps to shape and to catalyse the rate and the uniformity of the BIM's adoption process, lowering resistance and creating a clear timetable for its implementation (Wong, Wong, Nadeem, 2009; Cheng, Lu, 2015). This federal initiative is also important because in Brazil's cases of adoption by lower-level government bodies, inconsistencies, limits on applicability and conflicts with other actors in other fields were observed, resulting in a reinforcement of the resistances and objections to it.

This statement is corroborated by the fact that the federal legislation that regulates the all public bidding processes allows a great deal of uncertainty already in the the planning phase. The Law 8.666/93, which defines the procedures for public biddings, only defines in broad terms that it is necessary to have a "basic project" with information and degree of detail "sufficient" to start the bidding process (Brazil, 1993). These vague terms that fail to define precisely the required information open the door to a wide range of interpretations. The progressive reduction of the technical bodies of the public institutions, starting in the neo-liberal governments in the middle 1990s, and the existence of a large contingent of political indications of public workers (more connected to the individual administrations than the public service as a whole) creates the ideal framework for the actual scenario of corruption, waste and lack of expertise and unaccountability (Pita, Tramontano, 2017). Of course, we cannot attribute all the problems verified in public works solely to corruption; the failure to properly plan a complex enterprise such as the production of a public facility leads to a waste of resources, improvisation at the construction site and poor financial allotment. These questions, however, have a different nature than the corruption and misuse of the public resources; they can be mitigated with more precise standards and a tighter regulatory policy - uncertainty lowering actions that also benefits (but aren't sufficient to) the combat to corruption.

There is a direct association between this uncertainty and the problems discussed. At the heart of corruption, the processes are the basic question of power and control over information (Rose-Ackerman, 2004). The establishment of a prior agreement between the actors in the form of a secret that binds them at the same time that excludes others corrupts the republican relations that should prevail, based on the concept of transparency and accountability.

In fact, the word corruption itself in its Latin origins means "to break" and "heart", showing that a corrupt action is in fact an attack in the very core values of democracy and republic.

Sabet (2009) indicates that corruption is a "wicked problem", that is, a problem with undefined shape that adapts itself to the attempts to solve it. The author also states that the transparency of information and relationships among stakeholders is one of the few truly effective means of combat since the involvement of a large number of actors and groups and indiscriminate access to information destroys the very principle of the secrecy and opaque agreements between few. A secret is no longer a secret if there is no control over who knows it.

In this context, the research presented here aims to involve a greater number of actors in the production process of a public building. The introduction of these new actors leads to new behaviours and emergencies, which in turn can be incorporated into the ongoing process. To understand how such communication between actors with and without a technical background can establish a meaningful conversation, we used Gordon Pask's Conversation Theory and Edgar Morin's Complexity Theory as a theoretical framework, forming the basis for the understanding of the new proposed dynamics. These new dynamics bring with them a certain amount of unpredictability, which must be incorporated by the systems through clear standards since the excess of this unpredictability can lead the system to collapse.

This diversity, however, does not jeopardise the design process, quite the contrary. According to Morin, "their diversity is necessary for their unity, and their unity is necessary for their diversity" (Morin, 2005, p. 147). Thus, the more diversity there is in the profile of the actors and the roles they play, the more complex the system will be, and the more likely it is to develop a new organisation - an emerging phenomenon that can manifest itself as new ideas, products or new organisations. It is a question of favouring transdisciplinarity in the process, since even if it is considered that the myriad of professionals and disciplines that participate in the life cycle of a building possess diverse knowledge, this knowledge gravitates around the same subjects. Thus, non-technical actors contribute effectively to greater transdisciplinarity through an increase in the diversity of attributes of the actors involved. According to Nojimoto (2014), this diversity is manifested in the different visions of the world, experiences and knowledge of each actor. This new information manifests itself beyond the pure technical question, introducing other issues such as communication, work relations, motivations, personal interests.

The introduction of these new actors into the design process is not without difficulty. The high degree of complexity of a building's documentation can impede non-technical actors to have a proper understanding of the information, and to process it to have a meaningful conversation and contribute with new information. It is necessary to establish common communication parameters - a common language, which minimises the differences of understanding about the object. This language need not be only textual: Pask understands that in order for a meaningful transmission of this information to occur, to the point where there is almost certainty of a common understanding, there must be agreement among those involved in the use of a language. This language can be non-verbal, but have to possess a great semantic richness (Pask, 1976).

The architectural language is, par excellence, a non-verbal language, of great semantic richness. These characteristics must also be present, by extension, in any platform that aims to integrate these different actors. BIM objects can act as carriers of this semantic wealth itself, and the multiple ways of displaying the metadata contained in them (through geometry, or in the form of tables, or as graphs) allows the information to be understood more clearly between the different actors.

This "language" forms the basis of a common agreement, indispensable for this process of conversation. Continuing the parallel between the theory and BIM, by accessing the information contained

in the database, interactions immediately occur - between the actor and the platform and between the actors through the platform. Whether by viewing conflicts or splitting work areas, agreements are signed at all times, in addition to the common platform agreement. However, this agreement needs to be learned or adapted to another form of communication, different from the one used in the traditional design processes, and therefore requiring changes in posture and mentality concerning object of work and the relationship between the actors. If the boundaries between traditional design phases overlap in the process of adopting BIM, the very boundaries between the actors also become less precise (Succar, 2009). This flexibility is part of the initial agreement to operate on the platform.

This process requires interactions between the actors and the building of diverse consensuses that will shape the project. In this regard, the BIM platform can be defined as a system that contains these subsystems in interaction, with a common, predetermined goal. The information management and mediation of conflicts system represented by a collective of applications, databases, networks, etc. in interaction (which we associate with the BIM system) assumes the role of the controller of the process (Morin, 2005).

This incorporation of non-technical actors does not mean that there is a dispersion of the original attributions of each stakeholder, quite the contrary. Just as the BIM framework foresees an exchange of information between specialities, with the preservation of individual attributions and responsibilities, this must also happens on the proposed platform. It is not feasible to imagine that there is a reversal of the participatory processes underway on the platform: it is not a matter of commending the decisions of the community, but of establishing an open dialogue between actors. Thus, the platform must be designed from and for these stakeholders, and their specific attributes.

These groups of stakeholders, though interrelated around shared interests and roles, are not homogeneous in their demands and interests. Each individual acts in their capacity within them, leading to the emergence of leaderships, opposition, consensus and dissent, which may be explicit or not. As an example, within the agents of the State, constituted by the political agents and civil servants, there is a constant conflict. This conflict is proper to the constitution of the modern technical bureaucracy (Weber, 1994), in a movement of opposition of the hierarchical subordination versus the apparatus of legality that imbues the elected representatives with authority. These conflicts occur in a veiled way, and not infrequently deviations from the conduct of these political agents come to light through denunciations and oppositions of the state bureaucracy itself. Still, in terms of representativeness, these two groups are equally important, as they represent the various facets of the State and their internal conflicts.

This same logic occurs in all groups, in a process of dynamic self-organization as exemplified by Castells (2013). The proposed characterisation reflects this dynamic because many actors considered as part of homogeneous groups ("the government", "the community", "technicians") that act in unison, in fact, are only bounded to the groups' common goal in a temporal basis. These groups' agency capacity emerges from the abilities and interests of the individuals, and not the other way around. The proposed platform also takes this into account, and while some assignments are given to different groups, the different platform dynamics are intended to surface and expose the conflicts and agreements within and between them, once more aiming to level the playing field between the distinct groups and actors.

MATERIALS AND METHODOLOGY

As already discussed, the production process of public facilities is Brazil is determined by a set of rules and legal regulations and by the broader context of the civil construction. On the one hand, there is legislation defining the entire process for contracting and acquiring any service and good, establishing a formal environment where all intermediation with the pub-

lic power must necessarily occur.

In parallel to this formal process, there is a network of relationships and interests that define the decision-making capacity of the actors involved. These networks and chains were studied with the support of the literature and field observation of these processes, and confronted in their formal structure. The determination of these relations was based on the study of the formal governmental structure and recent cases of corruption in Brazil, not surprisingly involving large contractors, where the evident existence of a parallel route of decision making is present and necessarily not transparent.

Of all the characterised variables, are of utmost importance the technical capacity of these actors, that is, their intimacy with the language and the productive processes of a building. This criterion is fundamental, and characterised as a priority because if the information of the project is not understood in its nuances, there isn't already the establishment of a common language and the prior agreement of the conversation.

The second characterised variable is the articulation of these actors and the public sphere, since this determines their position in the formal structure of the productive process, indicating it position on the formal hierarchy, their decision power and controlling power.

Finally, the interest and economic capacity are important factors because it indicates the ability to influence decisions in an "informal" way, that is, to the detriment of the formal collaborative structure. This characterisation by definition is complicated and less precise since it involves frequently influence peddling, active and passive corruption, among others, which, due to their characteristics, have a non-transparent mechanism.

From the characterisation of these actors, the next step on the research was the development of a prototype of a platform with a common language and equal access to pertinent information, in order to allow a qualified dialogue, where emergencies may arise and new solutions and relationships established. To this end, the research is based on the concept of praxis, understanding theoretical reflection and practical actions of experimentation and application as inseparable and interacting. For this reason, it envisaged the construction of a computational application, in parts that are being tested several times in situations analogous to real ones. Each cycle test feeds back its revision, contributing to its validation and the legitimation of the procedures adopted, and at the same time subsidising new reflections.

RESULTS

The productive process of public works in Brazil is structured through the action of several actors around a specific legal framework. The demand for a particular work occurs at the initiative of the public agents and of the executive powers, through the action of public agents (ministries, secretaries appointed by the elected representatives) or elected representatives themselves (mayors, governors). These representatives demand the construction plans to the technical staff of the public entity, which in turn either prepares the first studies and the draft or contract it externally. These technicians act as an intermediary between the public agents, the outsourced contractors for the project and for the work, and, to a lesser extent, the community or the users of the building.

In another phase, these technicians act as intermediaries and representatives of the public interest when dealing with these contractors. These, in their turn, execute the contract and deliver the building to the municipality, which operates the facilities in benefit of the final users. This is the workflow as defined by the legal bills, and is generally a transparent and documented process, as seen in the figure 1. Also, in this figure, it can be seen the tenuous relationship with the community at large, be it comprised of technicians or non-technicians.

However, some other connections take place in this context. Communication between these actors not always follow this formal chain, and some parallel, and undocumented relationships develop. These

relationships are charted in figure 2. It's important to notice that some of these non-official relations are also non-republicans, and form the basis of the corrupt or distorted relations that were discussed before.

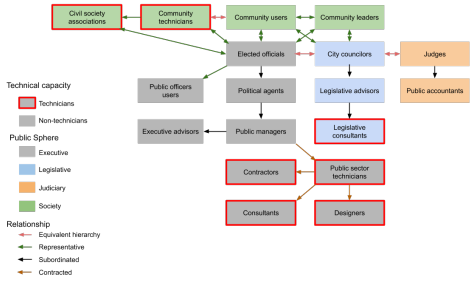


Figure 1
Formal relationships between actors. Source: the authors, 2019.

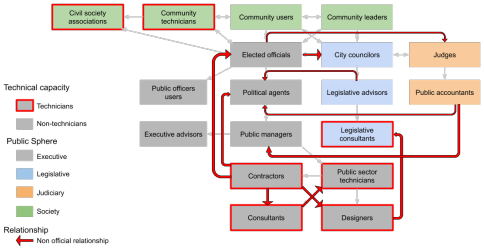


Figure 2
Informal relationships between actors. Source: the authors, 2019.

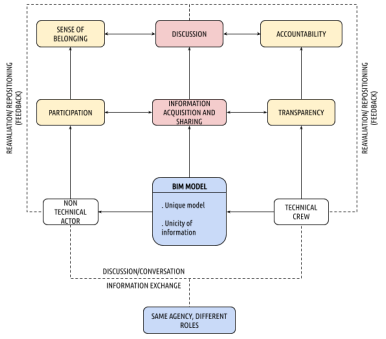


Figure 3
Conceptual information flux. Source: the authors, 2019.

The roles of the different actors are multiple, with the occupation of several categories. This result demonstrates the need to predict that the means and forms of understanding and access are multiple, and that there is a considerable contingent of stakeholders who have little or no contributory capacity in the current productive process.

The graphs show that despite the role played by technicians, the decisions do not always follow these criteria, and this dialogue is often directed by other means. The population and the users of the building generally don't have an active voice in the process, except at specific moments and linked to electoral interests. There are internal organising projects of these groups to maintain their hegemony and their position. This process is based on the control and capture of information by groups, which they share with others who share their ideas, in a secret pact.

The BIM as controller of the communication process has instilled in itself the premise of transparency and the accessibility of the information contained. Information niches diminish considerably among technical actors, and, according to our previous work, has the potential to extend this communicative capacity to non-technical actors.

In a way, transparency in the process stems from the very nature of the projects. The structuring of a coherent and productive conversation depends on the existence of a common language among the interested parties, a basic condition for discussion. Agreement with the rules of conversation is essential.

The figure 3 show the development and the platform concepts. This platform is operative in a prototype stage, passing through various stages of testing. It can be accessed at www.nomads.usp.br/bimnomads/en.

The proposed application derives and presents its information directly from the IFC file exported from the various BIM applications. This direct connection is important to minimise the possibilities of tampering or occluding relevant information, which can occur if this translation is delegated to an actor. This principle maintains the integrity of information,

which can be verified in every stage of the process by the myriad of IFC checking and compliance applications.

This information must be presented in a meaningful way, and the platform makes use of adequate the more medium in every moment, without overwhelming the non technical user. For this end, the production process is divided in moments, analogous to the actual phases of project, but with a crucial difference: in every of these moments there are preferred subjects of conversation (implantation on the site, preferred spaces distribution, specifics needs of the community) but all information is available and presented in a simpler way, in the form of a simplified interactive 3D model and all metadata contained in the objects, comparative tables, etc. This helps the establishment of the common language.

Every one of these moments is open for the input of every actor, in the form of a parallel discussion about the current subjects (where the interactive 3D model is present to inform this discussion better) or in a completely independent forum where every subject can be discussed. This last forum is important to foment the self-organization of the different groups.

At last, the individual attributes of every actor are preserved in the form of the different roles they play in every moment. The discussion forum assumes the role of a public hearing of sorts, registering every manifestation contained. This status means that one cannot comment anonymously; the registration of the individual actions is important to generate a greater sense of responsibility and accountability. Also, every moment is divided in smaller moments where all objections and proposals must be answered by the public sector, being it by the technical actors, being it the representatives. This dynamic is necessary to preserve and to account for the attributions and responsibilities of every actor, and to create a meaningful discussion. In these moments, no new comments or discussion can be initiated by the community, but the general discussion forum is active throughout the entire process. These moments and the general structure of the platform are shown in the figure 4.

CONCLUSIONS

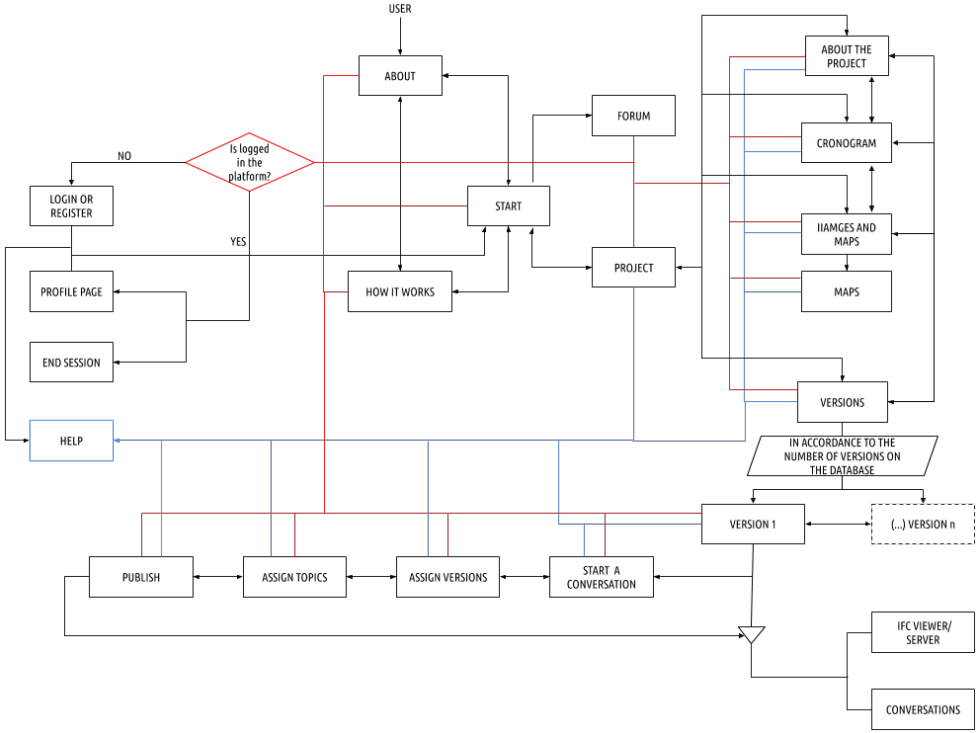
We reviewed the literature and through observation determined the groups of interest involved in the production of public facilities. These groups are not homogeneous and have internal dynamics and attributions that cannot be ignored.

We determined that accesses to information and the possibility of having an equal agency capacity is necessary to the platform, independent of the technical knowledge and the position and relation between them. To obtain this equality of conditions, the information needs to be transmitted in a common code, capable of constituting itself in a single language where the consensuses and dissensions can manifest without noises on the communication, initiating a dialogical process.

At the practical level, this translates into an interface that provides non-technical actors with the possibility of understanding the project and the work in its specificities and generalities, minimising the interpretative efforts on the part of these actors. On the part of technical actors, there is a need to preserve their role and responsibility. Finally, on the part of public managers, the function of mediation between society and the community must be maintained, since it is not intended that the platform be transformed into an instance of direct democracy.

The application also does not intend to replace or overlap with the processes of participation and control already established, but to operate in parallel with these, allowing the addition of a dimension to the involvement and collaboration of the non-technical actors. It is not ignored that the implementation of these processes depends on initiative and changes in the structure and form of the operation of the official bodies - for example, if the projects are not elaborated or contracted with the use of BIM by the government, there would be no possibility of interaction with the model required by the application. In addition, the space for debates must have attributions equivalent to those of a public audience,

Figure 4
General structure of the platform.
Source: the authors, 2019.



with a record of the actions and acts of all those involved, under the risk that the platform becomes only a propagandistic instrument or become just the legitimization procedure of pre-defined decisions, which is a common criticism of existing devices.

This participation is relevant not only to the constitution of a participative and fiscalizing culture of the State acts, but also as a means of including in the decision-making processes inputs and possibilities of new solutions that would not be otherwise available. In short, through this participation, new opportunities open up and the accountability of public agents is broadened, as well as a sense of belonging of the community at large.

Thus, the process that takes place at defined moments, where there is the provision of the information necessary to discuss the elements placed at each moment, with the availability of the three-dimensional model with the appropriate degree of detail. At these times, it is up to the administrator and public representatives to organize and encourage discussion, and provide general guidelines such as budget, available staff, etc; and the technicians, the obligation to respond and discuss the decisions taken with the other actors at every moment, in a transparent way. This discussion takes place in a single discussion forum, with simultaneous access to all the information about the project, whether these are textual, such as tables, schedules, budgets, or techniques, represented in the 3D model and the metadata associated with them.

It is hoped that this platform can add another layer of transparency on the discussion of a complex object as public spending in facilities. It aims to over-

come a crucial problem in the effective participation of the community in its production process: the technical language barrier. The advent of the BIM opens up the opportunity for that overcoming, and its implementation have deeper significance for the public involvement, specially in countries where this participation is not common. The platform, however, cannot be a simple gimmick or a chancelatory step of the public decisions, with the risk of it becoming irrelevant in the long term. Thus, the intimate relationship with the BIM, being adopted at a federal level, and the status of the platform as an official public forum are important to achieve the aim of creating a relevant discussion, where emergences, transparency and accountability can happen.

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