Guest Editorial Preface

Special Issue

BIM the Technological Breaking of the Civil Engineering? A Synergy Industrial Research, Academic Research

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The texts gathered in this special issue come from a research workshop of EduBIM Days 2017. EduBIM is a small community of teachers and researchers in France that meets every year to share its pedagogical practices and its contributions to BIM. The goal is to pool this knowledge production and capitalize on it, in relation and in exchange with the European academic network. At the origin of EduBIM, is the industrial research project MINND with which the relations of collaboration continue.

The MINND project is an industrial project bringing together 68 partners, certified by the French Ministry of Ecological and Solidarity Transition, but self-financed by the partner companies. The aim of MINND is to produce research work specific on BIM and in particular related to the infrastructure and focused on structuring and exchanging data. The industrial partners delegate more than three hundred contributors, participating in working groups that deliver deliverables to each phase of the project which lasts about 18 months. The MINND project had the need for academic interlocutors that allow both a specific dialogue with laboratories each partner and welcome trainees, PhDs, but also a collective academic interlocutor that allows to capitalize knowledge, to prioritize academic research leads. This led to the creation of EduBIM with the academics involved in the project.

It is rare to see industrial research and academic research facing the same agenda. In general, the tempos are different. A sudden irruption of the technological breaking can lead to this forecast planning of research as well for the teaching community, as well for the industry. But Industrial research and academic research are not organized around the same processes.

Scientific research is organized around the central process of the peer review process. It formulates avenues of research based on hypotheses that take into account the problems perceived in reality but also in the theoretical achievements of the discipline and its related disciplines. Topics that emerge are related to individual choices, influenced by incentives such as funded projects such as European projects, but choices remain individual on specific issues designed in relation to a research community and its published work. The contradictory debate allows not only to confirm the good orientations because they are taken up by other authors but also to eliminate the bad leads by a contradictory debate, sometimes rather hard. The exhaustion of the debates allows to generate new debates and to make new contribution emerge.

Industrial research projects, whether European or national, usually work by consensus of a group of engineers and practitioners. In industrial research, research questions emerge from immediate and concrete perceived needs in companies. Industrial research projects attempt, in general, to write questions of research that juxtapose themselves and provide a global response, they attempt to build a set of lack of knowledge that permit the resolution of concrete problems. The subjects are less conceptual, broader and closer to concrete applications than the subjects of academic research. As they express less abstraction, they do not claim to contribute to scientific debates that go beyond the sector but aims at this alone application framework.

But the two complement each other, when they can dialogue at certain opportune moments, it is fruitful for both. The texts of this special issue IJ3DIM are marked with this double imprint.

How to interpret BIM, as a phenomenon of technology and evolution of the discipline of civil engineering? how to characterize what we live as an engineer, builder, software publisher or teacher? In a quick way, there are three main visions: some actors see it as a change of software versions, others as a technological breaking or others think it is a paradigm shift for the civil engineering discipline. Let's look at these three possibilities.

Can BIM be just a change of software versions? A significant change, but ultimately only an evolution of computer tools? If this were the case, we would not observe any evolution of the working methods, no change of way of reasoning, no change of relations between the institutional roles of the actors.

But it's a whole approach, ways of working together, neutral standards, etc., that are involved and that we observe. The magnitude of the consequences: all the interfaces and exchanges are impacted, the ways of working together, the reorganization of the project work. These consequences have been prefigured by other industrial sectors such as the automobile and the aeronautics industry and by the mechanical engineering evolution. The ability of very large databases software platforms, greater computational capabilities grow up the capabilities of multiple representations, calculations and simulations which become complete and simultaneous access. Finally, the change of the means of dialogue between the actors lead to the modification of the distribution of the institutional roles of the actors inside and around the project.

Of course, software evolution is an important component and a fundamental resource of change. Software editors make evolving their ranges. Client companies are demanding a complete compatibility of versions, organize evolutions of know-how of their collaborators and ask for a broader interoperability between software editor. The extent of the questioning, the universality and the diversity as well as the depth of the impacts (all the activities, in all the markets, all the sizes of company) seem to disqualify this vision. We will conclude that BIM is not just an evolution of software.

Is BIM a technological breaking? BIM is the form taken in the construction industry by the wider technological breaking, it is in a way the absorption of technological breaking by the civil engineering. When can we talk about a technological breaking? It's an increase in processing capacity of machines and new technologies like scanning that enable BIM. Powerful modelling tools, coming from outside the field of activity and the discipline come to upset the modes of calculation, of modelling of the discipline. The technology repositioned the way of modelling and calculating and simulating massively all calculations and models. It is the power of the machines which allows the digitization, which makes it possible to pass from the CAD to the 3D representation, but also to the mode of decentralized access of the info in the form of platforms and network, the management of the simultaneous accesses, the power of internet exchanges, and that of large databases. This set of technological possibilities integrated and put at the service of the tools of the BTP produces the BIM.

BIM in its three meanings, both the numerical model of a building or infra, the numerical modelling process and third the management of the numerical modelling project can therefore be defined as a set of procedures, processes and technologies interacting between them and creating a methodology to manage the data of a construction project in a digital format throughout the project lifecycle.

It will be objected that the fundamentals of the discipline such as the calculation of structures are not questioning, but the simulations around the solutions tested under different scenarios and the fact that they are accessible, including trades that do not make calculation of structure, reshuffle the cards. The best solution will not necessarily be the best solution with regard to the only criteria of the structural calculation. But that, considering the requirements of the structural calculation, considered in a systemic point of view and taking into account several subsets of constraints composing the context of the choice. The field of the "one best way" is still restricted. Concurrent engineering and the possibility of massive simulations (Teulier, Garel) moves local optimizations and simulations into a global context analyzed as a system. It therefore seems difficult to deny this technological breaking that impacts the sector and the discipline of civil engineering (including urban engineering). We will therefore validate this first observation in our argument: BIM is the translation in Civil Engineering and in the construction industry of a wider technological breaking that has already impacted others industrial sectors. However, can we go further and talk about a paradigm shift for civil engineering?

Can we go further? Are we also witnessing the emergence of a new paradigm in Kuhn's sense? that is, a vision of the world that provides postulates and working methods, in other words a coherent set of laws, theories, applications, and experimental devices. A new paradigm must provide models that give rise to particular traditions of research. And we observe that the BIM also modifies the experimental protocols, and the conditions of production of the knowledge, for example on specific universe description as that one of roads.

What Kuhn shows in his book "The structure of Scientific Revolution." The process of developing science is not only cumulative. From time to time, breakings occur. A paradigm is not rejected as soon as it is refuted but only when it can be replaced. In the case of BIM, we are witnessing a replacement of old concepts and methods by the new ones.

The paradigm shift often comes from within the discipline or from a fundamental theory that is a pillar of the discipline. But not always, Artificial Intelligence at its creation is built on the postulate that the processing of information can be modelled by drawing inspiration from cognitive processes, hence the importance of cognitive psychology, then neuro sciences. The paradigm shift is more conceptual and deeper than a technological breaking.

If there were a paradigm shift for civil engineering, what could it be? For instance, on the shift from the line to the object. This is not just a drawing component, it can be considered a graphic inscription that modifies human thinking in the sense of Goody. On the use of digital modelling tools, visualization, data format storage data, the use of cooperative work in a context of concurrent engineering. Can we conclude that we are seeing a paradigm shift? we wanted to open the debate, it is difficult to decide because it is an engineering, so even more dependent on science and methodologies neighbouring than other disciplines. And because, on the side of the industry, it will be difficult to distinguish, in the observation of a "new paradigm" what is the evolution of the discipline and what is related to the organizational processes and the economic conditions of the sector

The fact that the civil engineering discipline is precisely an engineering has many implications. As an engineering, it cannot get away from practices. And like all engineering, it makes many borrowing to other disciplines. Let us return to the definition of civil engineering as a set of scientific methods and tools, construction techniques that allow the calculation and design, the construction of structures and infrastructures. It is based on general scientific theories and methods and deals with themes relating to materials and structures.

But it is true that the very components of engineering in the act of designing and building that are modified. In other words, the conditions, the way we will do the calculations and the methods we will use. It is not only a building or structure that will be provided but also a model, or a digital twin that is up to date exact data that will have been identified during the construction. The act of building on the building site therefore has two outputs and two deliveries: a physical work and a set of digitized data updated and organized so as to be useful for the next stages of operation and maintenance. Academic research in engineering is possible. It does not boil down to applied research.

Its scientific purpose is to propose new concepts, methods and tools for an engineering constructing actions organizations or artefacts using a coherent corpus.

What can we observe in this transition toward the adoption of BIM and the evolution of the industry on the period? Civil engineering as engineering is upset by the BIM and must be rebuilt as a discipline. But it does not be summarized by BIM. The new civil engineering will not only evolve as a scientific discipline but will also see the recording of the production of its knowledge (concepts, tools and methods) in the practices of an industrial sector, very quickly. In what will be integrated in the practices of the professionals, one will have at the same time evolutions resulting from the research in civil engineering, and others of the practices themselves evolving.

Some profound conceptual changes are already perceptible and widely recognized. Changes already seen in other sectors such as the automotive sector (Midler) are confirmed, for example the fact that the project teams can correct errors and dissonances in design at the beginning of the project, when they are much easier and cheaper to repair. and not at the end of the project. The fact of not working in partitioned silo but to broadly communicate from the first phases of the project is already observed and will not be questioned.

Among these changes: the structuring of data around the object representation, structured into an object, property, attribute, value revolutionizes the way of thinking. Through the object, it is the representation of the working universe that is played, but above all the fundamental change is the object thinking that accompanies it. The description of the universe passes through both objects and concepts, terms that apply to all and must pass not only from one software to another, but also from one business universe to another business universe. The need for a glossary to make the parallel of objects in texts and to name things, to describe the common universe with precise words (but contextualized and evolving) and understood by all is felt. The need for an evolution towards true ontologies seems less mature in the works that can be read on the BIM. The need for interoperability is deep and generalized. Interoperability between software is obvious but there is also the interoperability of models and mutual understanding between job point of views. Finally, let us quickly mention the fact that the modelization processes and the status of the model change in the new civil engineering or the visual aspect of the 3D models and the simultaneous connection of the actors, which makes it possible to make this shared visual perception at a distance.

Other topics are less present now in debates and research on BIM but will emerge in the coming years. The competitive advantage sought by companies will also be repositioned and recomposed with the BIM through the way each will be able to compose in a new way the know-how and knowledges of its teams and its services offer. The composition of business models will therefore evolve in the sector. These two topics for example could give rise to works in the management sciences. Likewise, all innovations (smart roads, etc.) will only be produced in the context of BIM. For the moment, the adoption of this one obscures in the debates this need to innovate. Individual and collective skills, training and methods of team composition are starting to spark some works. Finally, some themes have been addressed in a partial way. Cooperative work and concurrent engineering, the notions of PLM, life cycle of the book are already studied. But some aspects such as the integration of points of view in cooperative work around BIM have been little studied. Cooperation involves understanding the other's point of view, integrating one's agenda and constraints, and integrating them into one's own action plan. Similarly, the implications of working in cooperation, whatever the teams, projects or occasional groupings of firms (consortium to respond to calls for tender) are little studied.

We can conclude that it will take time for the transition to BIM to be widespread and mature, and the construction sector will take time to integrate approaches and tools. The competitive advantages of companies will be recomposed in several stages. The new civil engineering will reuse more and more the partial models in a systemic way and repositioning the different methods against each other. The decompartmentalization of the various specialties of the discipline, the obligation to co-operate different trades implies the sharing of concepts, knowledge that are transverse, as a first demonstrative example we can think about ontologies that are adopted little by little.

Achievements such as object reasoning, the transition from the plan to 3D visualization, concurrent engineering will not be questioned. The combination of cognitive processes and interfaces will be perfected by integrating assistances that we do not talk about much like those allowed by AI. Some topics that have not been seen so far in the BIM: cooperation, the modification of the business model, the evolution of the professions, in Abbott's sense, will probably be tackled in research, even if we can regret overall the weak contribution of the social sciences up to now. The new civil engineering will take shape little by little. Under these conditions, it is understandable that industrial research and academic research are upset concomitantly and continue to find reasons to dialogue.

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