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Strategy for the implementation of BIM workflows in SMEs regarding team collaboration. Case study éBRICKhouse

Estrategias para la implementación BIM en pequeñas y medianas empresas relativo a trabajo colaborativo. Caso de estudio éBRICKhouse

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I ABSTRACT

Recent advances in Information Technology have led to the apparition of a new working methodology called BIM (Building Information Modelling). It brings important advances to an industry, the AEC, which is characterized by its complexity and fragmented nature.

Nevertheless, for the effective implementation of this technology, it is required not only to learn and use the software, but also to reinvent and adopt the workflows, methodologies and the roles and responsibilities that the employees have. Additional attention is required to the concept of collaboration, since it is considered an essential skill in BIM and little importance is having in current academia.

Although some frameworks for the implementation in companies have been proposed, most of them present general guidelines without going into the subject in depth. Furthermore, the implementation in large companies started earlier than in Small and Medium Enterprises (SME), despite they represent an important sector of the construction industry.

In this context, this dissertation aims to present a deeper analysis of the framework, proposing workshops and activities for the fostering of BIM and team collaboration in SMEs. An analysis of a case study is carried out for a better understanding of the framework since the implementation of the BIM depends on many factors and differs from one company to another. The complexity of creating a common framework becomes more difficult and the framework should be personalised.

I.I KEY WORDS /ACRONYMS

BIM: Building Information Modelling/Management

AEC: Architecture Engineering Construction

SME: Small and Medium Enterprises

BEP: BIM Execution Plan

IFC: Industry Foundation Class

MVD: Model View Definition

COBie: Construction Operations Building Information Exchange

VDC: Virtual Design and Construction

CDE: Common Data Environment. Related with:

- PIM: Project Information Model
- AIM: Asset Information Model

IPD: Integrated Project Delivery

BIS: Business Innovation and Skills (UK department)

VBM : Virtual Building Model

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1 INTRODUCTION

Building Information Modelling (BIM) has been stated the future of the construction Industry (Agarwal *et al.*, 2016; Tauriainen *et al.*, 2016). Many benefits have been proved that this technology brings to the industry, based on the ability exchanging information and reducing costs.

It is logic to think then that the interest of implement this technology in the AEC Industry has grown exponentially since the apparition of BIM some years ago. But this process could result more complex than expected and it takes time and experience to achieve it.

On the other hand, BIM has been proved successfully in other industries, because it is not just for buildings (McCool, 2015). Nevertheless, it is also true that the construction industry is not like other industries that they have been mechanized. Because it is very difficult to mechanize the construction process, therefore it has not changed too much since the beginning.

The past of the construction Industry could be resumed as everybody was working for themselves, instead of making groups and sharing information. Along the years, the construction increased in size and complexity, making necessary to mix disciplines and work together with different experts. This process it has been always very difficult, slow and inefficient, and the workers have been to overcome these difficulties for a long time.

Some years ago, the construction Industry was in need of change, and that reinvention came along with the apparition of BIM: new technologies and new methodologies related with collaboration. BIM can be considered as a tool, and there has been a tendency to fall into the mistake of thinking that it is just software, but the truth is that, irremediably, it has influence on the methodologies. BIM has been in the industry enough time to highlight the problems and disadvantages the actual work processes have, so direct questions are addressed: *Are there frameworks for BIM implementation? What influence have BIM in a company's workflow? How related are team collaboration and BIM? Are the professionals ready to BIM?*

The intention to answer these questions, and the certainty of knowing the importance of the SME's in the construction sector, guided the development of this dissertation.

2 BUILDING INFORMATION MODELLING

2.1 What is BIM?

Theoretically, too many things have been written about what is BIM, but it is not always easy to explain. The NBS expose this definition of BIM: "*BIM brings together all of the information about every component of a building, in one place. It makes it possible for anyone to access that information for any purpose, e.g. to integrate different aspects of the design more effectively. In this way, the risk of mistakes or discrepancies is reduced, and abortive costs minimized."* (NBS, 2017). In other words, BIM is an innovation in the construction processes. To easily understand it, we can think about a traditional project. The differences stems from the view that, in a BIM project, this one is combined with technology to give a product that integrates, not only the representation or the model, but all the information of that it requires, in order to make it easier the process from the beginning until the end.

Normally BIM is understood as a way of modelling, but it is more than that. Maybe it is because of its name, BIM, which means Building Information Modelling, which it leads to confusion. But in the name is the key. BIM is the relation of a model, a project, a 3D view, with the information, a database. A BIM model without information it is not more than just that, a model (Mordue *et al.*, 2016). Other times it is viewed as a software, but it is important to understand that it is not just that, it covers furthermore, such as the methodologies, or the way of creating and managing all the information along the project. That is BIM, too.

Along the years, project managers, architects, engineers, they had designed and they had graphically represented their ideas. The degree of strictness in their work determined the successively errors in the building site, but sometimes it was inevitable. With the introduction of BIM it came the opportunity of building the project twice, that means that it can be reproduced the construction process virtually, way before it starts (Mordue *et al.*, 2016). This let the user to have a global comprehension of all the processes that will occur, checking the errors or consequences that may happen.

Example of the possibilities that BIM can offer is the possibility to test the interferences between construction elements, but what is more important, these mistakes would be detected very quickly, letting time to solve and offer other options. For management it is a very useful tool, too. It helps to avoid overlapping between teams and it makes easier the coordination. In conclusion, it helps to anticipate to the problems, and at the end, to construct in a very effectively way, reducing time, costs and risks.

For the correct implementation of this technology it is necessary to have clear that it requires a list of "elements" or characteristics for BIM to success. One of them it is to be supported by Standards, theoretical framework or methodologies with proven results. Other is to wager for the digitalization of the work and have open mind to new technologies. It is essential to have a clear vision of the work and the processes used. Only with this type of analysis it would be possible to see where the weaknesses are and the way to introduce changes to improve. Finally, it is essential to count with a trained team, with people able to understand the new processes and software.

2.2 The benefits of BIM

BIM adoption and implementation can be challenging and difficult at the beginning, but it will bring several benefits, and all of them are related or can be summarize in one: increasing of the efficiency. Communication between parties, when collaborating in a same project, can make the design phase much easier with BIM. All the participants in a project may have a see the project with a different view, and a BIM model can give answer to everybody, simply and fast.

One of the main benefits that BIM offers is the better management of the information. (Migilinskas, et al., 2013). This is because all the information it is digitalized, so it is quicker the access to it, and the data is more precise. This reduces the time of checking processes and improving with changes. Therefore, the model evolves in a more efficient way.

The digitalization of the data produce other benefits, such as the ability exchanging information. Multiple workers or teams can use or modify the same data at the same time, and see the changes up-to-the-minute. With multiple teams working in an interdisciplinary project, it exists a high risk of overlapping and development of designs that are impossible to work because some components intercept with others. This problem it is not new in the construction Industry, but BIM developed a tool to facilitate the discovery of that, and it is known as "clash detection".

The loss of information is less probable with BIM, for the same reason. The easy access to the information it is effective across all the phases of the project, not only during the design. Take into account that the magnitude of some big projects makes to become very long projects. Subsequently, the decision-making and the information that managers have to handle is huge. The possibility of checking information anytime they have a question or they are debating about problems that appear, for example, on site; that possibility is priceless. Going further, BIM it is useful even after finishing the construction. It is expected to be a useful tool of maintenance.

For the people unconnected with the AEC Industry, BIM has benefits, too. In this category they are included clients (not always they understand about construction), consultancies, investor, etc. With BIM tools, it is possible to translate a project in different "products" easily understandable for non-experts. A 3D view with the consequently nongraphic information, can be easily prepared for a meeting with a client, and this one would understand much better the concept. Or a simulation of the operation of a kind of installation it is easy to do with the correct tool. This kind of things makes process very clear not only to non-experts, but to the ones calculating and working on that, too. A BIM project can be translated into numbers, too. Exact calculations about costs or lifecycle can be done directly from a unique file, just with one "click".

Another definition for BIM could be "the possibility of build twice: one while projecting, the digital construction and later the real one". The "first build" is called that way because many simulations about the behaviour of a construction can be done. A very interesting application that BIM offers is running a simulation to test the lifecycle of the building or to calculate and reduce the carbon emissions. The results are very accurate, thanks to new levels of detail and research done about the topic. This is an important improvement, and decisions can be done taking into account the natural environment.

The simulations can be focused to address other aspects, such as the health and safety. They can be essential, especially in dangerous projects, to understand areas of risk and provide solutions in order to protect the life of the workers.

From all the benefits explained above, it can be deduced the most important benefit: The efficiency. BIM is efficient because, basically, it reduces risks and time.

It is redefining construction and setting the basis of what will be the future of the industry. New concepts related with it appear every day, and it is demonstrated that BIM has still lot of potential to develop. This is demonstrated through new applications that appear and the fast improvement of the existing tools.

2.3 Time – effort distribution curve.

Construction industry is known because of its low productivity, its wasted effort and its backwardness compare with other industries. The traditional way of work contributes to unnecessary loses and mistakes. According with Macleamy (2004) the problems are attributed to a deficient system where architects, engineers, contractors and surveyors do not necessarily interact during the Project Life Cycle (PLC), have competing interests and consequently work in an inefficient way. The same author implemented a time-effort distribution curve with the intention to illustrate how trough BIM processes these problems can be addressed.

Figure 01 shows the mentioned time-effort curve proposed by the author where is possible to appreciate 4 different curves: (1) Ability to impact cost and functional capabilities; indicates that the effort in bigger when the decisions are made during the design and construction process; (2) Cost of design changes; cost as far as the construction work progresses is higher as well as complete waste of time; (3) Traditional design process; this is how the effort is distributed in the traditional way where most efforts are invested in the construction documentation and management; (4) Is the new proposal where the new effort is focused in the schematic and development of the design under a full collaboration model from the entire project team.

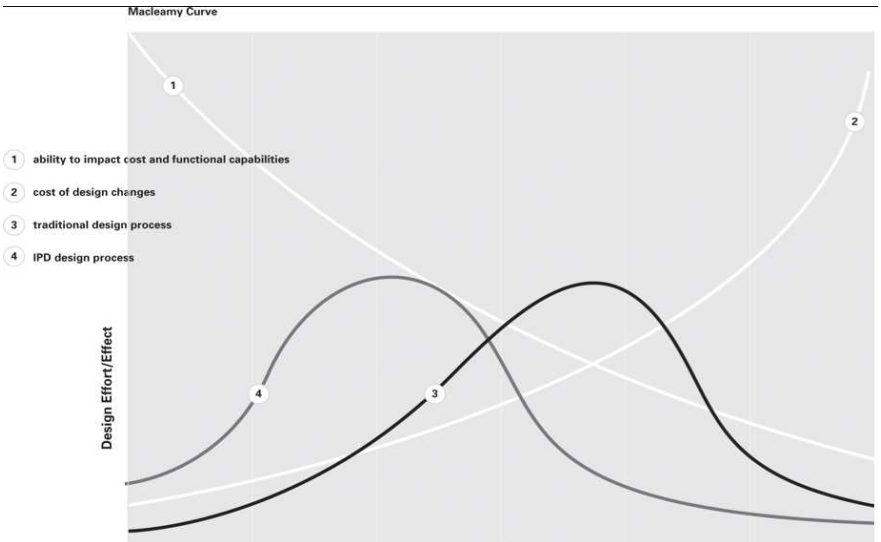


Figure 1. Collaboration, integrated information and the project lifecycle in building design, construction and operation. MacLeamy, P. (2004)

Only the fact of using the technology to integrate this new system is not enough. It is necessary to incorporate new processes and adapt the existing ones. It is a new sociological and cultural understanding of the PLC where the main goal is to stablish a new process of work (González et al., 2014).

These new process of work are focused on concentrate the maximum effort in the early phases of the project, when the impact of the changes are higher and the costs of made these changes are smaller. This is translated into a workload much higher at the beginning, but it will ultimately bring many benefits.

The MacLeamy curve could be compared with the effort when implementing BIM in a company or organization. It has to be hard at the beginning, but it brings profits that are worthwhile the effort.

3 BIM MANAGEMENT

Since the first time it was heard about BIM, this technology has changed very much, and it is continuously improving every day. And it is also true that the appearance of BIM in the Construction Industry has challenged it to evolve and change the way of thinking.

The correct implementation of BIM in the industry, depends on three factors, based on what McCool et al. state in their book: *"BIM and Construction Management: Proven Tools, Methods, and Workflows*". These three key factors are: processes, technologies and behaviours. It is also another good way to understand what BIM is and what does, and it is true that taking one of these factors out of the view, we couldn't consider BIM as such.

Processes

The industry is formed by processes. And with the arrival of new technologies, managers tend to try to adapt new technologies to old processes. With this thought the procedure eventually creates more waste of cost and time, what is against LEAN and BIM philosophy. This is an approach it should be eradicated, because for a good functioning and better efficiency of the project it is needed to adapt the processes to the new technologies. If it is necessary, it should be created new processes taking into account the repercussion of the tools that currently exist.

With this statement, which one a lot of reviewers agree (Alreshidi, et al., 2017) (Migilinskas, et al., 2013), it is not saying that users should revolution and change completely the processes. At the end, construction projects has not changed that much, the same problems it had to be faced in "traditional" projects, they are being faced with BIM projects. The difference is that now with the new technologies there are some tools to quick repair or avoid them. For example, clash detection, it is a term that was born with BIM, but it has always existed. It was solved after long meetings, discussing between members; it is part of a process. Once a company decide to adopt BIM, managers could decide to maintain the meetings as a methodology to solve, for example, clash detection and it would derive to a waste of time. In the best of the situations, they would use the same time as in a usual project, but sadly, it is demonstrated that it would cost more time to understand the new tool, and more discussions about interferences would appear.

Nevertheless, changing this process and instead of working with the same type of meetings, the focus is in other aspects, this time could be significantly reduced. In addition, another way to proceed could be developing or using an existing tool to model in the cloud, with different users working at the same time.

It is necessary to keep in mind that BIM is a tool, and for the better exploitation of that, users should adapt the processes in their jobs. Innovation comes always along with changes.

Technologies

Technologies is the second key factor for the implementation of BIM, and it can be understood as the tools, software and hardware which workers interact in a BIM project. But the technology is changing very fast, every day they born new apps and software. This situation can overwhelm workers, so that is why it is essential for a team or an enterprise to know how to choose what type of application best suits their work. Also, in the same company it is faced different types of projects, so although it can seem a loss of time at

the beginning of the project, the election of a different software according to the type of project can save money and time.

As many authors have pointed out that there are three types of approaches in order to select the tools needed: The "pile on", the "swap out" and the one known as "process first". The first one is the easier and the least painful, but also the least effective because it can cause confusion. It consist in the addition of new tools to the old ones, and piloting the results of the integration. The second one consists in the replacement of the old tool after the examination by the experts. And the last one it is related with lean concepts. It allows the integration of the tool by asking first to the team about the current processes and tools. It is important to add that in this method it appears the risk of not finding the right tool, but the analysis it can be very useful to understand the needs of the team.

Behaviours

This factor covers the members, the team, people that have influence in a project or a company. It is considered the most difficult to change. Sometimes talking about BIM, it is focused in the tool, the technology, but who manages the tool is way more important. (McCool, 2015). McCool in this book emphasise the importance of the behaviour towards the project: it is much better to work in an open mind and motivational environment than in one that they are resistant to change or bored. It is important to highlight that BIM tools are based on collaboration, so the minds that are managing these tools should be open minds, enabling to stabilize good relations.

3.1 LEAN as a basis of BIM management

In the past century, with the industry revolution, the production system changed and it continued increasing with the apparition of everyday newer technologies. This growing needs to thank the apparition of the term LEAN in the 80s, based on the philosophy of working of TOYOTA production back in the 50s.

LEAN is a new model of thinking that focus in efficiency, producing better results with the minimum costs and waste. Many researchers have talked about this philosophy that is based in five principles: 1. Identify value; 2. Map the value Stream; 3. Create Flow; 4. Stablish pull; 5. Seek perfection.

Lean can be understood as a methodology focused on reducing waste from every phase of the work process, and, at the same time, giving extra value to the product.

Thanks to the change of vision of this philosophy, the industry in general have prospered along the years, but in construction it wasn't that easy. The construction sector is very difficult to regulate, so it is behind other sectors in standardization and other issues as information management.

But with the new technologies, this has changed successfully. LEAN is helping BIM to be introduced in the sector, because BIM need managers and management to be changed the way they work, and it comes along with LEAN. This philosophy of continuous improvement marks the tips that BIM management should follow, and together, they are turning upside down the sector. LEAN has plenty of benefits for the company in general,

but for the implementation of BIM, in particular. It helps to manage employees from different sectors and expertise, giving them a common framework to work towards a mutual goal. This means that improves the way the employees work in teams. This improvement is possible partially because it helps the participants of the process to understand each other's duties and requirements.

The usage of BIM and LEAN together can lead to a better product and, following that, a better grade of the satisfaction of the customer.

A lot of literature review have been produced about the symbiosis of BIM and LEAN, as Sacks et al. , which researchers highlight the principles of lean and others functionalities of BIM, and most of the interactions of both, were satisfactory. Also, the analysis of data in other researches (Tauriainen *et al.*, 2016) show that some difficulties usually happen together, but in all the cases, the use of Lean tools helped to solve these problems. In most of that, what is known in LEAN as "Big room", was the perfect solution. Big Room is simply another way this philosophy propose to help the information to flow between different teams, with a direct contact with each other. Another significant conclusion of this paper is that, against problems, it is more efficient to be aware of what it may occur, instead of adding new tools to avoid them. And this is possible with a continuously improvement of the management, that not necessarily requires lean, but it is highly recommended.

3.2 BIM management. Requirements

As it has been explained before, BIM involves three factors that are processes, technologies and behaviours. Nevertheless, for the success of the implementation it is needed the influence of other factors, more specific, but in relation with the three of them.

One of the requirements have something to do with the fact that the future, in this industry and in others, is digital. BIM implementation needs a change from traditional ways of working to new software and methodologies that include the new technologies.

In relation with the confidence in digital world, comes other elemental requirement: training. Many authors have highlighted the lack of the correct preparation in future professionals. (Rahman, et al., 2016; Uhm, et al., 2017; Becerik-Gerber, et al., 2011). The AEC Industry is complex enough, but with the arrival of BIM it is more difficult to manage. All the processes and methodologies will change, and everything would be useless if workers don't know how to manage the software or don't understand the methods. It is important to difference between two types of training: the technical one and the managerial one. It is essential to know how to use the software, but as important as that is to be aware of the changes in the procedures.

In order to withstand the difficulties of the new changes, it is essential for the company to have firm foundations, where everything works correctly as a gear assembly. At the same time, the capacity of critical view with the own work it will lead the company to make improvements towards BIM integration.

Although the AEC Industry and entrepreneurs are conscious that BIM brings many benefits, is not always enough to make them to undertake BIM. Many times it is necessary to have

another incentives or situations to force or motivate the change. The economic crisis has been one of the factors that have encouraged many private companies to adopt BIM. On the other hand, public companies have started the implementation much later, because the market is not that difficult and many times the client doesn't impose it (Porwal and Hewage, 2013b).

To finish, it is remarkable to examine, as essential requirements in BIM, two terms that have relation and very used in BIM-speak: Interoperability and collaboration. The first one it is consider the ability of working with information and/or outputs that a colleague of team have produced. Interoperability is the interchange of work and information, and this is, in essence, what we understand as "collaboration". The effectiveness of the communication depend on the "language" the workers use. In other words, the exchange of information will be fluid if every worker use the same standard formats and guidelines.

3.3 The importance of sharing. Collaborative work

As Mordue et al. and other many authors state, BIM is about a quarter part technology and guidelines, and three quarters behavioural. The basis of BIM is the management of the information, but the information is beneficial just if it is shared.

Traditional workflows in the construction sector were traduced as a succession of phases, and in every phase the owner, architect or contractor were the principal responsible of the project. The owner first proposed the program to the architect, and then the architect or designer started working with the pre-design. In this stage, the dialogue were just between the owner and the architect, and it was slow and ineffective. It has two reasons: the first one, the architect had usually periodic meetings with the client, but it wasn't a fluid process, and in many occasions the time in between was enough for the client to change the opinion. The second reason why this process wasn't very efficient, is because the lack of participation in this stage of other experts. The architect or the designer proposed the design without important technical advices or without the requests of the constructor regarding the materials, for example. That produced changes in later phases of the project, or the need of revision again and again for the architect. The same occurred in the project design stage. The architect or engineer in charge not always was the same in charge of the previous phase and the dialogue between stakeholders were almost inexistent. The conclusion: the process was slow and tiresome, and they were constant delays in the execution of the building.

BIM presents a different approach. It proposes and requires the involvement of all the participants in the project, at the same time and since the beginning of the project. It is translated to a more dynamic dialogue, and questioning aspects since early stages of the project and cooperation between teams. The workload at the beginning of the project is high, but the process will become easier as time goes by.

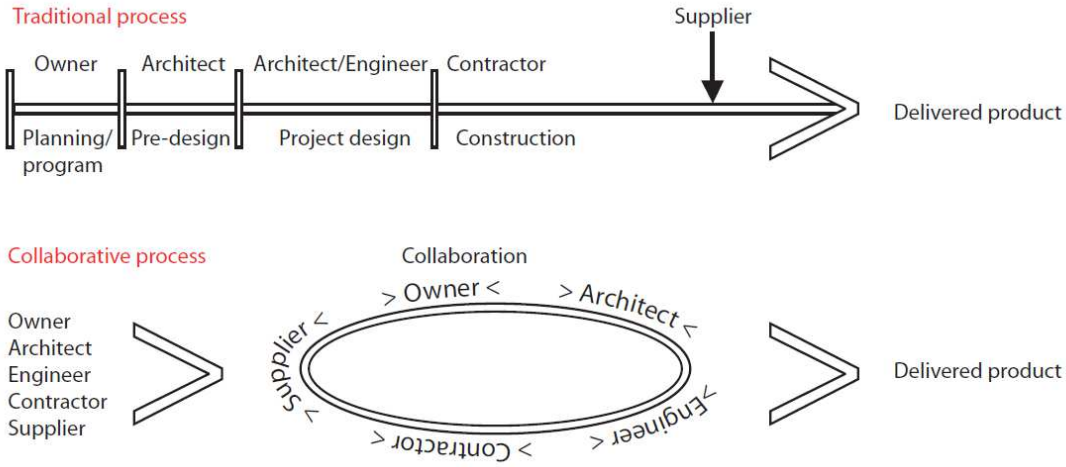


Figure 2 Traditional vs. collaborative process (Dansk Byggeri, 2005)

The intention of forcing to participate to all the stakeholders at the same time is the most challenging and most important issue that a company has to face for BIM implementation. This is because the construction sector has always been and it will always be very fragmented, and it is not sure that BIM would change that. It is possible that this technology will help to open minds and to understand better other positions, but the utopic idea of a total collaborative construction industry is still far from our days and out of the scope of this dissertation.

Collaboration in BIM has become a key concern for the academia and active professionals, because as it has been said, it is vital for BIM to thrive. It is convenient to encourage the habit of sharing information between colleagues since the beginning of the professional career. However, the complex process of design and construction make it difficult because every stakeholder have different interests and objectives, so they will focus their work according to that.

A totally implementation of BIM in companies requires the development of collaborative connections. This means that this technology can be integrated in a company, but it couldn't be considered real BIM without collaboration. In that case they wouldn't be reaching the full potential that it has. Many researchers have talked about the importance that collaborative work have in BIM (Lu, et al., 2014). They all agree about it is a key factor, but there are some differences of opinion if BIM is a collaborative technology or, instead, it is should be considered almost a philosophy of working.

At the same time, it is important to insist that it is not necessarily proportional the degree of implementation with the degree of collaboration in a company.

As it can be deduced from the previous words, the process of change from traditional ways of working is not easy. The solution should be trying to find common interests and making all the team work as a solid group, stablishing good working relationships. This is not as simple as it seems, because it comes into play a very variable factor as it is the human behaviour, and the relationships between members can affect positive or negatively in the project, and the influence can change depending on the situation. Due to the variability of this aspect, academics and professionals insist on fostering

collaboration frameworks or guidelines to add to higher education, and it is an aspect valuable in the industry for possible employees.

Many factors have influence in the implementation of BIM, as Amabile *et al.* (2001) resume in the figure below.

Figure 3 Collaboration determinants and outcomes (Amabile et al., 2001)

Although the cited study had the intention to apply in general, it can be extrapolated to the construction Industry. The researchers highlight the factors and characteristics a team should have, as professional skills and motivation, and the outcomes of the collaboration process will result in effectiveness and other important achievements.

An idealistic team work would function like this, but in many occasions it can induce into problems as the excessive amount of information. For an effective communication the flow of information should be sufficient and accurate. Exceeding the correct amount could derive to a lack of effectiveness. Also, the dialogue should be continuous in order to maintain the project updated and with clear information.

Another factor that a collaborative team should accomplish is trust: between individuals and between teams. Unfortunately, introducing new technologies affect the organizational structures and that, at the same time, to the reliability of stakeholders and the effectiveness of the collaboration.

To summarize this chapter, BIM is a technology that it would be useless without the dialogue, both formal and informal, between stakeholders since the beginning of the project. It is a tool for making decisions in the process, and subsequently, it fosters collaboration between members.

4 BIM ADOPTION

4.1 Maturity levels

At this point of the introduction of BIM, it is accepted that the implementation of this technology should be progressive, so that is why some proposals for the categorization of BIM have appeared. This is known as the "maturity levels" of BIM, originated in the UK, and many authors have talked about it. (Porwal & Hewage, 2013)

The UK is one of the countries that have investigated about this, and it has adopted the classification, proposed and studied by Mark Bew and Mervyn Richards. A visual example of the concept is the figure of the *"Bew and Richards Maturity Diagram"*, shown below.

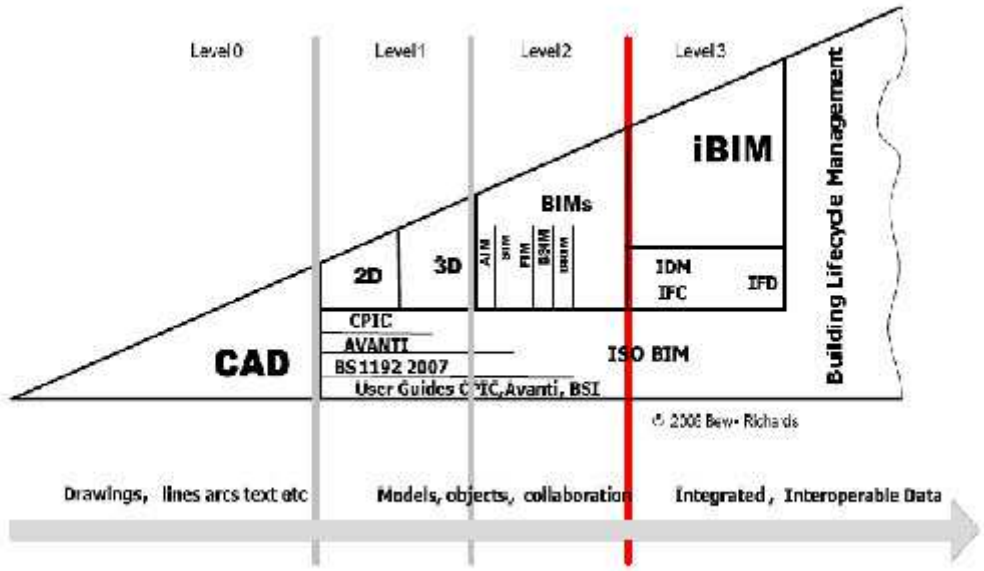


Figure 4 BIM maturity levels. (GCCG, 2011)

In this diagram, it can be differenced four levels, represented by vertical lines that cut the triangle. As the level of implementation increases, more concepts are covered.

Most of the companies dominate the level 0, when all the outputs are in 2D CAD and it is not necessary collaboration between different teams. A step further, level 1, it is produced the starting of the 3D models. It is the level where most of the users are currently working. Some methods related with collaboration are included.

Level 2 BIM integrates the interoperability and collaboration. The UK government has the target of integrate until Level 2 in the construction industry of the country.

Overpassing level 2, the level 3, represents the total collaboration between disciplines, the integration with ISO normative and the management of the information in the cloud. It has to be a target for later, and it means important andvances.

4.2 Standards and legislation

The standardization in general, is focused in the development of technical specifications, for anyone who want to use them voluntarily. These specifications are proposed and studied by a recognised organisation in order to make sure that they are reliable and contrasted information, and it obeys all the legal aspects. These organizations work creating committees with qualified experts in the matter of the different topics.

ISO and IEC are responsible for the development of standards that are applicable internationally, but in Spain, AENOR is the organization in charge of that.

AENOR, at its level, participates in the job of BIM standardization in international standards.

Focusing in BIM, the development of the regulation is still in process. Until now, the most recognized is the "Industry Foundation Class" (IFC). It is defined by the ISO 16739, *Industry Foundation Classes (IFC) for data sharing in the construction and facility management industry*.

Model View Definition (MVD) ISO 29481-3, *Building information modelling. Model View Definition*. This ISO is not relevant at first stages of implementation, but it will be explained later because is an interesting tool for sharing information.

Few Standards are already completed, and many of them talk about technical issues, but more ISO Standards related with BIM management are missing.

ISO/TS 12911: 2012 Framework for building information modelling (BIM) guidance

ISO 22263: 2008 Organization of information about construction works. Framework for management of project information.

Among all the countries that are investing in BIM implementation, UK is considered one of the most committed. In terms of development of legislation, they have the PAS 1192-2, that it is considered the most complete standard of our days and it is used as a reference for other documents and researches

4.3 Problems and barriers BIM has to tackle

Construction industry involves many disciplines and professionals with multiple backgrounds. The labour of integration and coordination is the major issue it has been facing during years, and in many projects with waste of money and with a delivery behind schedule. With the apparition of BIM, it was intended to solve, or at least help, to manage this problem. It has been already exposed the benefits it will bring when it reaches the full potential. However, to accomplish this goal, BIM has to face another problems, apart from the proper fragmented nature of the construction industry.

Maybe the principal scope a BIM manager and all his team should achieve is team-collaboration. In other words, interoperability or information exchange. An effective dialogue between teams in the same work is the insurance for a successful job.

Possibly because it is one of the main problems that a normal project has to face, with BIM implementation, where the importance of the information is so high, it gets worse. In a project it appears another issues related with interoperability: the risk of losing information, issues related with trust, ownership, misunderstandings, and Intellectual Property Rights.

Apart from the lack of collaboration skills that the workers have, in general, the formation of the staff is not sufficient and in many cases is not well managed. In relation with that, it is highlighted the lack of a support in which it could be analysed and described the different jobs related with BIM.

At present, it exists a certain offer of courses and masters related or about BIM. It is said a "certain" because they are proliferating new courses without the guide of a legislation. This is a problem because the new courses have deficiencies in some aspects and new professionals are unprepared. It is essential to create a framework to conduct studies related to BIM and set the basis of job competencies (Uhm, et al., 2017). For that, a deep analysis of the necessities, requirements of knowledge about BIM in different job title should be done. This is what makes that so important, the lack of a standardised framework has produced the apparition of many "job titles" that they cannot be certified. Nevertheless, new courses have been showing up, despite the lack of standardization, because the demand is growing every day.

Most of the offer of courses in relation of BIM focus their programs to the use of the software. The truly useful aspect of this technology it is not just knowing how to manage the software. This part it is important, of course, but the best skills working with BIM computer programs are useless without the correct management. For the right implementation of BIM it is required significant changes, not only training and learning new software, but reinventing the way this business work.

Precisely this is the most problematic setback that a company has to face. The process of adaptation the current workflows to BIM. This process has to be tested to choose the best procedure that suits the company. During this process, the manager should confront the resistance to change that may present some of the workers, and make them understand the high potential and benefits it present against CAD drawings.

BIM also requires a higher level of networking, and it makes necessary the apparition of a "coordinator" with BIM skills. It is a complex figure, the BIM manager, because it has to manage all the project information, coordinate the parties and help in the BIM adoption.

4.4 Difficulty of coordination all the parties. Bim manager and project manager

As it has been mentioned before, BIM has not been introduced in the curricula properly. This is a process that governmental organizations should study and introduced in the school.

But as it is known for now, and thanks to studies and daily work, there are some skills that "traditional" Project Managers and Bim Managers should share. It helps to understand both figures and how to success in the evolution from one title to another. (Rahman, et al., 2016).

It can be simplified the difference between them thinking that a BIM manager is a project manager with BIM skills. It is easy to think that because it is proven that the management is basically, the same as always. Traditionally, managers are responsible for people and processes, but the lack of knowledge about BIM, and the issues it produces while implementing, it makes necessary the creation of a figure to help workers with this technology and the managers to adapt the processes.

There are many discussion about if BIM manager and Project Manager should be the same figure or two different ones, and it is not clear. Many experts state that a project might be better with the participation with the two figures (Rahman, et al., 2016). On the contrary, many authors are faithful to the idea that the BIM manager it is only a title that will exist until this technology is completely integrated in construction. (Uhm, et al., 2017) They state that BIM managers are introducing new skills, and some of them will disappear with the "label" of BIM, and the project managers will adopt other skills related with BIM integrated in their work. About this discussion both ideas could be valid, but just with the time, standards and experts opinions we will know.

But what it is important from now on, is to deeply analyse both of the figures to set the basis of the efficient educational programs. As it has been displayed before, the lack of standardization have produced the misunderstanding about the skills and competencies a BIM manager should have. About this topic, some papers have been published, for example: "Comparing Building Information Modelling Skills of Project Managers and BIM Managers based on Social Media Analysis". In this study, (Rahman et al., 2016),the authors analysed a series of professional LinkedIn profiles related with BIM. They focused on the ones having the job title of "project manager" and "BIM manager", identifying their skills. They came to the conclusion that the project managers and BIM managers share more skills that the ones that they are just typical of their work.

They came up with an interesting table of skills that project managers and BIM managers should have for an effective work. Of course this study is rigorous in the methodology, but the sources can seem subjective. It is true that the ones with better knowledge of this technology are the ones used to it, but it exists a certain confusion and some educational companies take advantage of this to create titles that there are not certified.

Project manager	Project manager and BIM manager		BIM manager	
Metal fabrication	3D	Drawing	3D modeling	MEP
Modeling	Architectural design	LEED	3D studio max	MicroStation
New business development	Architectural drawings	Mixed-use	Construction safety	Piping
Steel	AutoCAD	Navisworks	Facilities management	Sketchup
Steel structures	BIM	Revit	High rise	Urban design
	CAD	Space planning	Interior design	
	Comprehensive planning	Steel detailing		
	Construction drawings	Submittals		
	Design research	Sustainable design		

Figure 5 Shared and unique skills between project managers and BIM managers. (Rahman et al.,2016)

This table shows the results of a study, but as it is said, it is relative. Furthermore, this procedure to analyse both figures is valid, but maybe it is not enough to have a complete vision of the problem. Because of their background and skills, they would have a different approach when facing a project, and this will affect to the course of the project depending if the person in charge is a Project Manager or a BIM manager.

One of the main principles of BIM is the collaborative work, and for this, PM and BM have a different approach, too.

4.5 Strategies and tools solutions for implementation

4.5.1 Exchange information concepts and legislation

Common Data Environment (CDE)

It is a single source of information which aims to make easy the collaboration between the members of the project team by collecting, managing and distributing documentation of the entire project.

Several are the advantages given by the CDE: the reduction of time and cost of production information by shearing information; the combination of distinct working models generating any number and documents; or the ownership information even if is shared or reused, will remain with its author and he is the only one that can changed.

Industry Foundation Class (IFC)

According with many authors and users, IFC is the most widely recognized BIM standard registered by the International Organization for Standardization in its official Standard ISO 16739:2013. It is an open file format for BIM specifications that can be exchanged and shared among the different stakeholders during the project life cycle and collects processes, data, specifications, terms and dictionaries for the coordination of changes in the project. Its aim is to provide definitions to every object and contribute to transfer data between the design tools, calculation of structures, facilities, etc. This means that properties, quantities, classifications of every object are linked to the geometric information.

Model View Definition (MVD)

MVD is a standard collected in the ISO 29481 that define the methodology for the exchange of data between different programs and AEC agents during the project life cycle. It is a subset of the IFC published by Building Smart with a neutral mvdXML format. The methodology has been defined by Building Smart International through an Information Delivery Manual (IDM).

The main goal of MVD is to allow IFC implementations with high quality that will be able to satisfy an ex-change of data requirements defined in one or more IDMs.

Nowadays, along with Building Smart International there are other organizations and development teams that are developing different MVD. (Building Smart, 2017).

Construction Operations Building Information Exchange (COBie)

COBie is an international standard collected by the English normative BS 1192-4:2014 for data exchange which focuses on the non-geometrical data of the edification. The specifications identify which is the information that must be exchange at each phase of the project and reduce the waste associate with the traditional process. The idea arises from the need of the sector to optimize the deliverables of a project. With COBie all project information is homogenized and shared only in one type of format. It also helps to register

and capture project data essential to support operations and asset managers at the time in which they occur.

COBie data model is based in a subset of IFC and is represented most of the times by a spreadsheet or a structured template with different data that has to follow specific requirements of information exchange.

4.5.2 BEP

BEP is the acronym of BIM Execution Plan. This plan was proposed by the already discussed PAS 1192-2:2013, the standard that are using in United Kingdom.

The cited plan, it is a key element for the success of BIM implementation, and it is defined as a *"plan prepared by the suppliers to explain how the information modelling aspects of a project will be carried out"* (NBS, 2017).

It has two main parts, because one is developed before the signature of the contract, and other when the winning supplier is decided. What it means, the plan needs to be developed previous and post contract.

The pre-contract BEP is the step further to the Employer's Information Requirements (EIR) and the scope of this part is to explain the approach and demonstrate that they have the capacities to execute the project. In this stage it should be delivered a Project Implementation Plan (PIP).

4.5.3 Examples of framework of implementation

For the correct implementation of BIM in a company, it is required significant changes in the way of working, modifying the processes and training workers in new software and workflows.

The traditional way of working with CAD have some problems and limitations. The study of LEAN processes guide us to think that applying these problems it would disappear.

Little research it has done about implementing BIM in SMEs, and even less with a real case study. Luckily, it exists some interesting examples (Arayici et al., 2011).

In the cited paper, Arayici et al. propose a methodology to implement BIM in SMEs, in a constant collaboration with the practitioners, what is, the company where they were going to apply the framework. This is what is known as a KTP (Knowledge Transfer Partnership).

They started setting a basic process of four steps, an approach based on a "learning by doing" philosophy.

The first one was the Diagnosis. It seems an essential step, taking into account that to make any improvements, it is important to understand the way they work, they communicate in order to highlight the weaknesses, threats, potentials… This is what is known as SWOT ANALYSIS. Special attention should be put on the analysis of the type of

work done and the software, because it is very important to choose the BIM tool that best suits the company. Another important investigation should be done about the stakeholders of the company, because they are the ones that demand the outputs.

Figure 6 SWOT analysis (google images)

The second step proposed is the planning of the action. Based on the indicators derived from the analysis, and with the guidance of the research done, it is possible to suggest procedures to follow and test in the company. Inside the action plan, it is necessary to include the development of a system to exchange information. Existing tools can be used, and rules and procedures should be settled.

At this point, the next step is to prove the plan on the company, and make it while working for a specific project. This first pilot project testing BIM it is going to bring a high level of effort because many things should be taking into account, training staff and managing new software and processes. But next projects will be easier.

The fourth stage, the evaluation, it can be developed at the same time as the piloting, and completed once this one has been finished. In this stage it is important to highlight that the points the company should improve for the next time, but also check the benefits that BIM brings to the company.

Other BIM implementation proposals categorizes the process differently. In the case of the company Autodesk, it thinks that the implementation is based on three strategies: vision, driven leadership and Incremental integrated change.

With vision it is considered to have the ideas about where to go with BIM implementation. The authors of the paper propose some key considerations that are just a few, for creating a BIM vision. One of them is the vision of the company should have clear aspirations enough to join the different parts of the organization. Another is the necessity to questioning everything, having into account that some questions would be difficult to answer, but they are necessary to go further. In other hand, a framework for Bim

implementation should be methodological, and providing some milestones accomplishments, based on the progression of the implementation.

The second strategy that Autodesk consider necessary is to form a solid team of leadership. This is what it is known as BIM Manager. This team (or single person, as a manager), will have the scope to make sure that all the "vision" philosophy is correctly applying into the company, and is producing the desired outcomes. This team should accomplish a series of requirements, personally and in their work. This means that it should control that the methodology is followed, and, as it was explained before the duties of the BIM manager come from control the interdisciplinary communication to the quality control and auditing. With the third strategy it arrives the real transformation into BIM. It is the stage, when the vision is clear and the leaders are ready, when all the processes and workflows have to be studied and proposed to be changed and tested into the company. Because there is too much to address, the authors of the paper grouped the transformation into four high-level areas:

- Policies and strategies
- Change management
- Standards and processes
- Integrated BIM technology

This paper is not bringing a list of specific actions to implement BIM in SMEs, but it is setting the basis and declaring what is truly important. Having clear the scope of BIM implementation is the first step towards it.

5 PROJECT DESCRIPTION

As it has been demonstrated along the work of research in the literature review, there are many factors that have influence when implementing BIM in companies.

Since the beginning of BIM, too much attention has been put on the software and not enough in the management part.

Some authors have written about a framework for the correct implementation, but they haven't gone into detail enough. It is clear that they have set some guidelines and principles to start, and they have helped to understand concepts, unknown until now. But the complexity of this technological change requires more specific guidelines to facilitate the adoption.

The lack of specific standards to be supported hasn't helped either. Although new information about BIM is appearing every day, it can lead into confusion, because it is better to have a common standard.

The state of BIM in Spain point out that it is necessary to create a framework or guidance for the implementation of the BIM in companies that belongs to the same category.

Before the implementation, it is essential to study each organization, in order to make the process appropriate for each company. In other words, it doesn't exist a framework or standard that fits in every company or organization, and it won't exist, because every organization is different.

It has been cited the necessity of a common standard to regularized the implementation, but it is needed just for general procedures, to set the bases of the framework. For specific actions to develop in each company, they have to be developed according with the approach and the necessities of each corporation.

The process of BIM adoption has to be gradual, first with one project and if possible, a small project. The effort used at the beginning of the process is maximum, but from that point is decreasing until the end of the process.

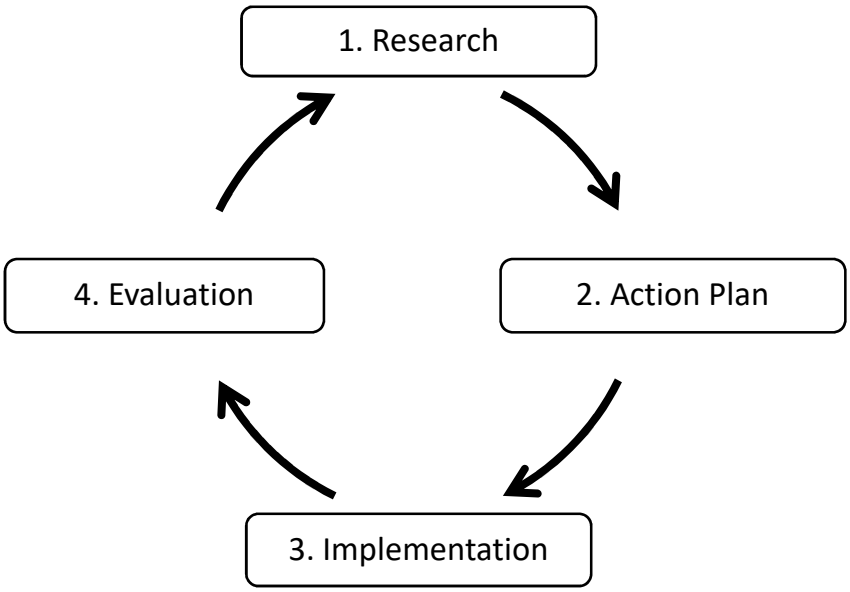
For the implementation in a company, it is going to be proposed four steps, but only two of them are going to be studied in this paper. The idea of four steps comes from the book *"Action Learning: History and evolution"*.

1 Research

2 Action Planning

3 Implementation

4 Evaluation



This cicled process it is known as "learning by doing". That means that it should be repetead until BIM is completedly implemented. The first step in the cycle is the research, to compile all the information about the topic, this case BIM and construction Industry. The next step is to design an action plan. This is, to develop the list of procedures, steps, activities for the implementation. Once the action plan is prepared, the process continues with the real adoption, the test of the plan in the company. During and after the implementation, the evaluation of the difficulties should be done, the fourth step. With this analysis of what went wroang and what went well, the process can start again, this time focusing the research in the necessities and changing the action plan where it fails.

Many studies have been published about implementation of this technology in a specific project, but not so many it has been written about implementation in companies. This is because it has to be a slow process, and it is important to start with a single project. From the single projects we could slowly understand where are the problems, where should be working and the weaknesses we should offset.

5.1 Methodology. The approach

Based in the literature review, there have been multiple cases of implementation BIM in companies, but most of them they have been slow and insufficient.

From these implementations it is known the problems that this technology faces, and because of that, the approach to set the steps of this framework it is conducted not to avoid them, but strengthen them, work on them to make the process easier.

These problems can be technical, or non-technical. The technical ones are easier to solve, with training and setting rules and procedures for all the labourers work the same way. But the non-technical ones are more difficult to solve because they involve the people's behaviour. The process of changing the workers' habits is very slow and it requires a

commitment from the professional working for the company. It is a mutual agreement between the worker and the manager, where they help each other and try to make it easier for the process.

As it has been developed before, there are some problems that BIM has to face when implementing BIM. However, there are three aspects that are considered the main problems for BIM adoption, and they are the ones it is going to focus this study for the approach of the methodology.

The first one is the bad formation of the workers. Although every company adopting BIM will find their workers have different levels of knowledge, the solution is the same: training. The approach to every employee would be different, regarding his current knowledge of the technology, the level of commitment and the role he will develop in the company.

Since the beginning of the dissertation, it has been emphasise the importance of the collaboration in BIM. As it is essential for the exchange of the information and the decision making, it is a common difficulty due to the lack of collaboration between teams and even between individuals. It is not an easy problem to overcome, but also not impossible. As it requires a process and it involves people, it is proposed the realization of workshops. The design of them it will depend on many factors, so they should be adequate to each company.

The complexity of the construction projects reaches a higher level with the introduction of BIM, so the difficulty of coordination all the parties become a problem much higher. In this situation, comes into action the figure of the BIM manager, but for the success of the project it is thought that are other aspects that have influence: to have a clear vision and to learn and set the procedures. It is like that because the methodology and the processes change with BIM, and if every worker follow the settled steps, it will be easier to coordinate.

5.1.2 SME'S and BIM

SME´s represent in Europe a vital part of its economy (eurostat, 2017) creating around 85% of new jobs. Particularly in construction sector, up to 18 million jobs are created by SME´s and this represents the 9% of the GDP contribution to the European Union. Therefore, the awareness that SME´s are taking among BIM will be the key to lead construction towards a full BIM expansion.

Government is pushing the SME´s in different European countries towards the implementation of BIM standards and normative. Some other countries have already put in force this normative. In UK is obligatory since 2016 to present public projects in BIM format as well as in the Scandinavian countries, in Germany there is a BIM plan driven by the private sector and supported by the Government, in Spain it is expected that by 2018 the BIM format will be required to contract public administration projects (AENOR, 2016).

But the reality shows that most of these kinds of companies in Europe are still working with traditional workflows of project management, where 2D drawings made in AutoCAD and those who are in transition towards the implementation of BIM methodologies are in a lower level of knowledge. A survey carried out by (Ghaffarianhoseini, 2016) indicates that in UK, country where it is mandatory to use BIM standards, 75 % of SME´s in construction sector are in an infant level and among them only the 25-27% are using BIM software's and they have a complete understanding about them. This leads to the question about

which are the best ways to implement BIM practices or if the ones that the companies are using nowadays are the most suitable for it.

5.2 Methodology. Based on workshops

The intention of the methodology is to help SMEs to implement BIM. In these companies, where the number of members is usually small, it is usual and very important for each member to have a global vision of the work of the company. And the value of the collaboration between members and teams is higher. That is why the activities are focused on the collaboration.

The companies that this framework pretends to be useful for, they have educational purposes, or the managers have the concern of the importance of the workers to have the most accurate formation.

Due to these factors, the research made and the successful experiences in real cases, lead it to think that the best way for the implementation is to set steps to follow based on workshops.

Several are the workshops and seminars that have been created during the past few years with the intention to implement BIM inside Small and Medium Enterprises (SME´s) construction companies (Construction Research Institute of Malaysia (CREAM), 2014). Most of them with the main goals of propagate the knowledge and principal characteristics of BIM, discuss the issues and challenges of the implementation of the program and which could be the strategy and the way forward for SME´s.

It is necessary to establish the principal aim of the workshop an present a reasonable approach with the intention in demonstrate the process. As Cretu, Stewart, & Berends (2011) stated, especial attention should be paid to the integrity of the workshop. This integrity may be affected if several elements from outside or inside influence the data and these dactors lead to loses of credibility.

The workshop process has to be easily executed and understood, neverthereless the most importatnt part of it is related with the atmosphere rather than the technical aspects. Every participant could freely participate in the workshop and has to be responsible for their inputs. According with the same authors, to be successful in a workshop the executive level-decision makers depend on the results of the workshop, the training that the participants could have before the workshop starts and the capability to analize and track the results in specific intervals. The preparation of the workshop could take several meetings. It is essential to establish the best combination of participants.

5.3 Framework

The proposed framework, it will be explained hereunder. It consist of a series of steps or stages that will help for the introduction of BIM in a SME. It is compulsory to complete every stage before the start of the next one.

It is important to remember that this framework is pretended to be used by SME's or similar organizations, what it means, that the number of workers and managers may vary between 10 and 250 employees, but not more than that.

The preparation of the workshop could take several meetings. It is essential to establish the best combination of participants.

Some guidelines are proposed through the four stages, but for the successful implementation of BIM in a company, the activities should be personalized and adequate to every situation. There are many factors they have influence in BIM adoption, such number of employees, type of projects, country, among others. Even the personality and behaviour of every person has influence. That is why it is proposed a framework with general indications, but for the better understanding it will be applied to a specific organization.

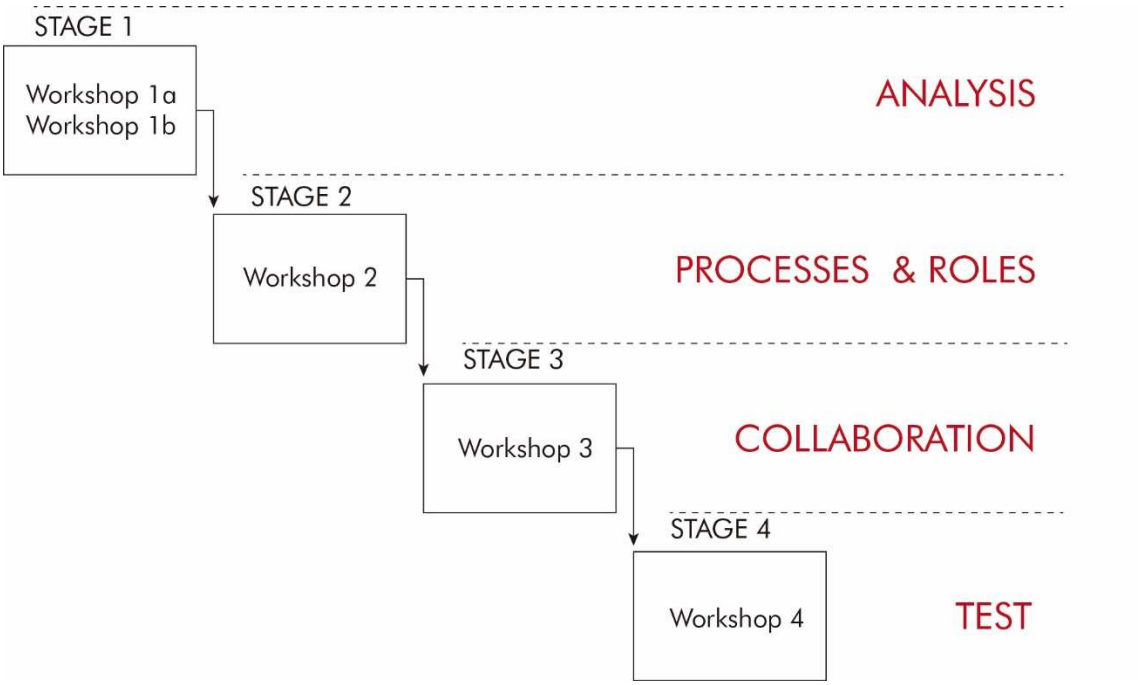


Figure 7 BIM implementation framework proposal (Self-produced)

5.3.1 Stage 0

It is the initial point, and it starts when a company or organization wants to implement BIM successfully.

Normally, when the head of the company decide to adopt BIM, is because they know it, so at least they have a general idea. It follows that managers could have knowledge about BIM management, although it is not necessary to be technical experts or domain the

software. It is advisable that the rest of the employees have at least an idea of what BIM is, but it is not compulsory.

In any case, it is required that all the employees have a global vision of the work in the company. Procedures, policy and software, among others. Of course, the implication will depend on the job title and responsibilities of the employee.

5.3.2 Stage 1

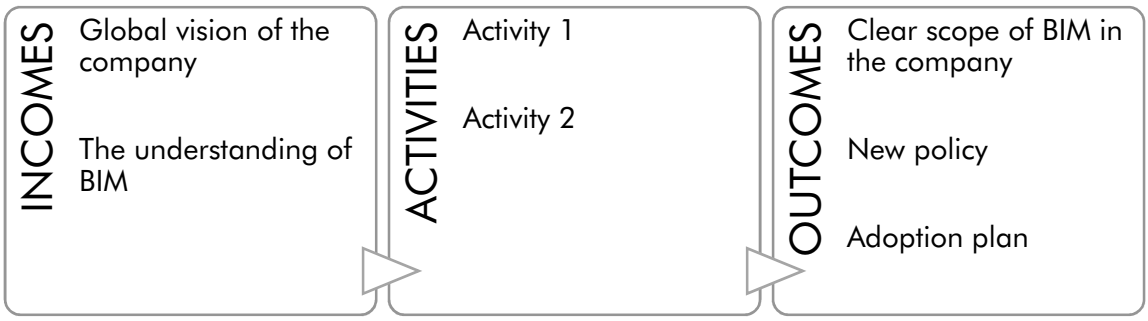
At this point, before to join all the parties, some organization management should be done, and make sure everyone knows what is BIM. So, that is why two types of workshops are proposed to start. One, organizational, for the managers, and the other more technical, for the workers, to introduce them into the methodology.

WORKSHOP 1a.

This first workshop needs the engagement of the managers and /or a representative of each team. They know the company better than nobody, and that is a requirement to start. As it was said, the managers probably have knowledge about BIM. If it is not the case, they should be introduced previous to this activity.

Both, global vision of the company and the understanding of BIM are the incomes with which the participants will realize some activities in order to achieve the outcomes.

For the definition of the framework, the outcomes have to be settled in every stage. In part one, the correct comprehension and realization of the activities will lead to the understanding of the influence of BIM in the company, the generation of the new policy and first decisions about new procedures will be settled.



Inside the workshop 1a, three activities are proposed, and each of them with a clear purpose. They can be developed the same day or in a couple of sessions. It does not matter as long as they fulfil their purpose.

Activity 1. Comparison and debate among all the participation about the global vision of the company. A dialogue should generate and every participant should share their own understanding of the company rules and functioning.

Depending on the size and scope of the company, different activities could be developed. Previous studies demonstrated that SWOT analysis is an excellent tool to have this clear, because analyses Strengths, Weaknesses, Opportunities and Threats. A participative debate could work too.

Independently of the method used, there must be some outputs, and they should be differenced in bullet points. They have to be recorded, or generate a physical proof of that. It is advisable to write them during the meeting, and a very good option is to dispone of a blackboard to fill with annotations, or a big banner.

Activity 2. Once the comprehension of the company is unanimous after the activity 1, the participants should make another analysis: again about the organization but this time about how it would be affected by BIM.

If they correctly proceed in the previous activity, they should have a list of important points to start. The way to proceed is going one point by one, making questions about the influence of BIM. For example, if the participants highlighted the lack of collaboration, try to think about the influence could have BIM in collaboration.

With all that information, managers and other participants should be able to decide how far they should go about BIM implementation. They should also set milestones and plan the process of adoption. For that, a calendar should be done with dates and the expected achievements or levels of maturity. In addition, during the discussion, the current policy should be analysed and changed.

WORKSHOP 1b. Rest of the workers

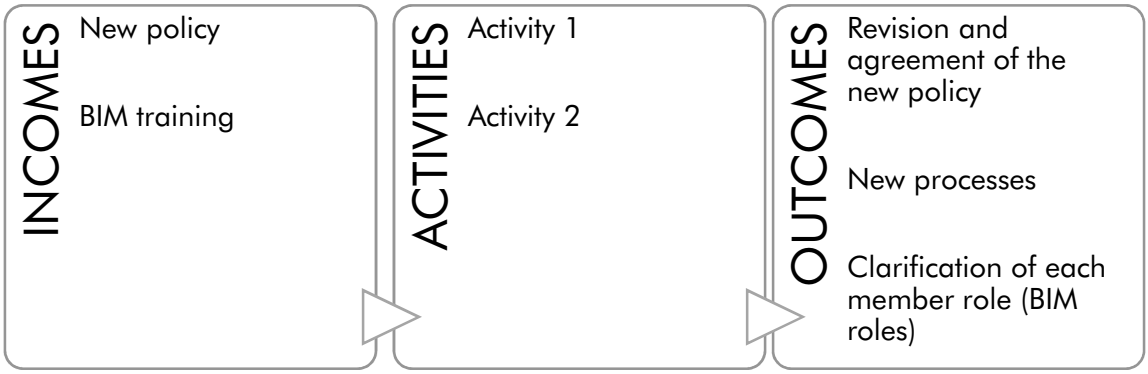
The proposal of this workshop is for the rest of the workers, the ones that are not participating in workshop 1a. It has be focused to teach software and BIM basics. This workshop should start with making the employees to understand the possibilities this new tool has, and continue with useful technical information, according with their role in the company.

5.3.3 Stage 2

The starting point at this stage are the outcomes of the previous workshop: Clear scope of BIM in the company, new policy and an adoption plan.

In this occasion, all the members of the company should participate. Depending on the number of people, the organization of the workshop may vary. In any case, the outcomes should be the same: Revision and agreement of the new policy, stablish new processes and make clear member role (BIM roles)

WORKSHOP 2



Previous to the start of the activities, the managers will share with the rest of the workers the outcomes from the previous workshop. What is stablished are guidelines and it has to be open for debate and to the rest of the workers to present alternatives or changes. Depending on the size or complexity of the company, this previous step could be considered as a different activity, or a simply meeting to update.

Activity 1. Based in the new policy and the plan of implementation, debate which ones should be the procedures to follow when working with BIM. According with the procedures, the suitable software should be chosen, too. All the team should analyse the current processes and tools in order to understand the needs of the team.

Activity 2. The scope of this activity is to try to clarify how much have BIM changed each member responsibilities. The second key point of this activity is to make the workers conscious of the importance of the figure of the BIM manager.

Although during the state of the art it has been said that there are not clear the BIM roles and responsibilities, some information exist. The moderator of the workshop can use the existing guidelines, but it advisable to follow the next steps and generate a debate about that.

1. Define the type of projects
2. Organise the work teams
3. Study the life cycle of the project
4. Set the BIM roles

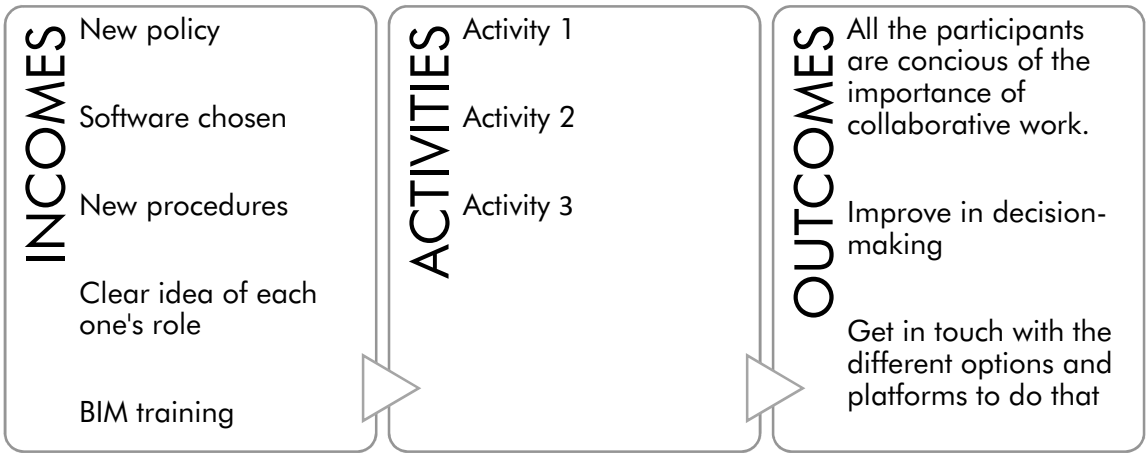
All the four cited step should be thought, having into account the effect of BIM. Respect the order of the four steps will help to find conclusions. At the same time, a special attention should be done to the figure of the BIM manager, because it is a new member in the company and not always their responsibilities are clear.

5.3.4. Stage 3

Once the policy and the vision of BIM and the company is clear, it is time to educate the workers in the necessity and efficiency of the collaborative work.

As this stage, as the previous ones, there are some incomes that are the result of previous stages. In this case, at this level, the company have already an improved policy, it has chosen the adequate software to their work and new procedures. At this stage all the members of the company will participate in the workshop.

WORKSHOP 3



Activity 1: The first activity of the stage 3, which it is dedicate to foster team collaboration, have the scope of analysing the processes and check if the exchange of information is correct. The idea is to create a debate with every member pointing out his point of view.

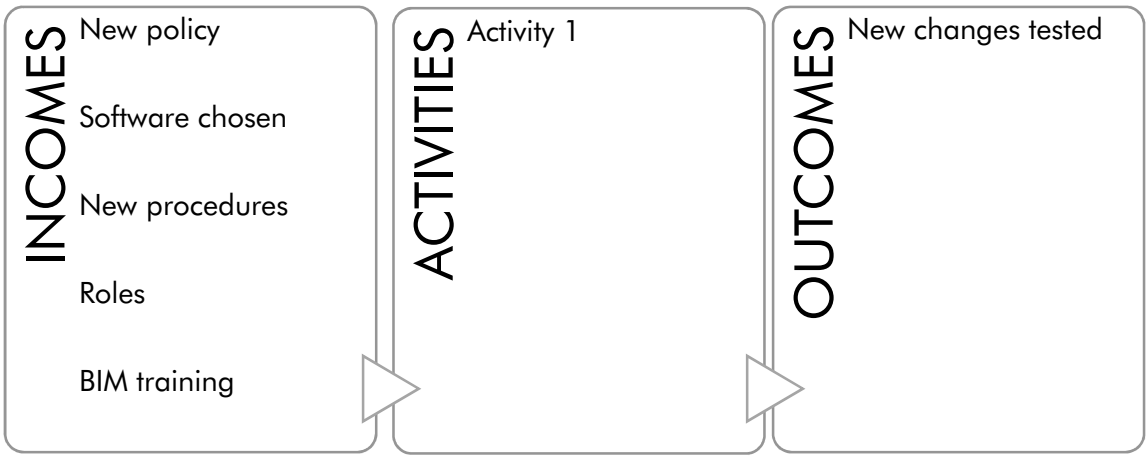
The participants will work with the outcomes from the Workshop 2, the processes and the responsibilities of each employee. With those outcomes, a deep analysis of the relations and exchange of information should be done. The particular outcome of this activity is to reconsider the processes taking into account the collaborative work.

Activity 2: The second activity will be dedicated to solve the problems related with the decision making. This is a problem that appear in every project and is related with collaboration.

Activity 3 (optional): At this point of the workshop, the progress of the activities depend on the mood of the participants. This is a good occasion to relax a little and propose a game to strengthen work team. It doesn't have to be related with BIM. The important aspect is to make sure that the teams work in harmony.

5.3.5 Stage 4

WORKSHOP 4



Activity1. Simulation of a real project.

In this activity is also necessary the participation of all the workers. As in previous activities, depending on the size of the company, the workshop will be developed in teams or individually.

The idea is, with all the information debated since the beginning of the process, check if it will work by doing a simulation of a real project. It is obvious that it couldn't have the same complexity as a real project, so the proposed construction should be something simple. What it is important is to check the methodologies, and not that much the project itself.

For it to be successful it is important that every member know their role, the new policy and procedures. Everyone will adopt their role in the project, except one person for each team. These participants will have the mission of an observer, highlighting the possible problems that could appear.

The correct development of the activity should include the proposition of the steps to follow, the debate of the possible problems may occur and the solutions.

6. APPLYING THE METHODOLOGY IN A REAL CASE:éBRICKhouse

The case study it is proposed, is not an usual SME, but it works like one. éBRICKhouse is a non-profit organization composed by students and teachers from both universities Universitat Jaume I in Castellón (Spain) and VIA University College in Horsens (Denmark). The team, apart from the students and teachers, it is completed with researchers and multiple companies that participating and sponsoring the projects.

éBRICKhouse design, teach and build. So it is not only design. The strategic idea of this organization is to help for the first contact of the students with the future in construction, and the participation and discussion of ideas and solutions. These are desirable skills for their professional future. In addition, the opportunity of building themselves what they have designed, let them a better understanding of the construction.

The projects they use to participate are the competition Solar Decathlon (https://www.solardecathlon.gov/), because the purposes they promote match with them: students' training and education, and the energy efficient construction.

6.1 STAGE 0

As it has been explained in the previous chapter, this is the starting point, when the organization wants to implement the BIM tool to their work. In order to start the process is mandatory to have a global idea of how they work and the methodologies used. In comparison with SMEs, this organization with teachers and collaborators making the paper of managers, and the students play the role of the employees.

The image below resumes perfectly the way of working of the organization, where the different disciplines work together under the supervision of the project management area.

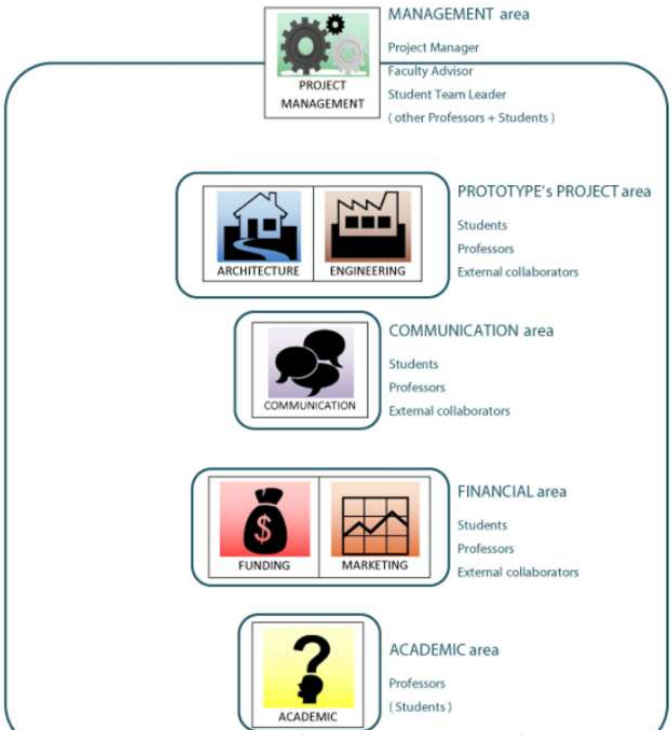


Figure 8 éBRICKhouse organization chart

This is the organization chart of the Ébrick house. But when they face a project, they come into action more stakeholders as company represents and other collaborators, so the scheme becomes a little more complex.

6.2 STAGE 1

So at it was described the chapter before, this is the first point to start the planning. It has two parts, two workshops.

6.2.1 Workshop 1a

For this workshop the presence of a moderator will be required. It could be anyone out of the organization. The management team will meet and with one representative of every work team. The final list of participants and their role in the organization should be described:

TEAM MEMBER	DEPARTMENT
Teresa Gallego	Project management & academic
Eduardo del Olmo	Execution Manager
Agustín Lozano	Architecture
Axel Pena	Engineering & Financial
Oscar Griñó	Health and safety
Javier Ares	Marketing

Activity 1.

The idea is to create a debate for the deep understanding of the working in the organization, and listening to the view of it from other partners. A SWOT analysis of the organization is proposed.

The mediator would start displaying a big blank table like the one below:

From this point the debate should start, each member giving their point of view and pointing out as a team the different aspects: strengths, weaknesses, opportunities and threats of the organization.

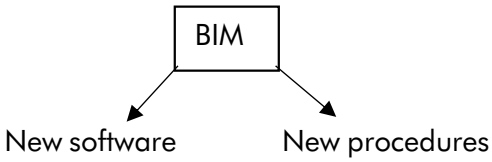
In case of block, the mediator can help making questions to make them think in the right direction.

When the participants agree in a point, should write it down where applicable.

Activity 2:

With the previous analysis, the same participants would analyse the influence of the new tool. Taking advantage of the situation, they will discuss about the limits of the implementation, in other words, they will decide how further they want to go with BIM.

Taking the previous consensual SWOT analysis, they will analyse every strength, weakness, opportunity and threat, taking into account that BIM means new software and new procedures.



An example of the procedure could be to ask at every strength: How does BIM improve this strength? Or at every weakness: How can BIM help to overcome this weakness?

A discussion should derive from this activity, and all the outcomes should be registered and with an easy access to every member.

6.2.2 Workshop 1b

éBRiCKhouse, as a part-educational organization, will probably teach their students about BIM methodologies. In that case, the realisation of this activity would be reformulated.

6.3 STAGE 2

6.3.1 Workshop 2

Activity 1: As it was stayed in the framework, in stage 2 is time to consider the processes. An activity that can work with this type of organization is trying to make a process tree. The idea is to build the map, taking a couple of tasks and see how they interact. The activity is recommended to have a moderator, and make all the members to participate in the creation of the map.

Activity 2: According to the proposed framework, in this activity there are four steps.

1. Define the type of projects
2. Organise the work teams
3. Study the life cycle of the project
4. Set the BIM roles

The first one is to analyse the type of project. In this case, this point is clear that they use to prepare sustainable proposals for the solar DECATHLON. So, it should be taken into account very carefully the importance of energy efficiency and BIM.

Although the organization chart of éBRICKhouse is already clear, it is important for the participants to follow the steps in order to understand the final outcomes. So steps 2 and 3 shouldn't create too much trouble.

The important step is the fourth, to set the BIM roles. For that, every work team will complete the next table and they will discuss internally the contents.

ROLE	NAME	RESPONSIBILITY		INTERACTIONS
		Principal	Secondary	

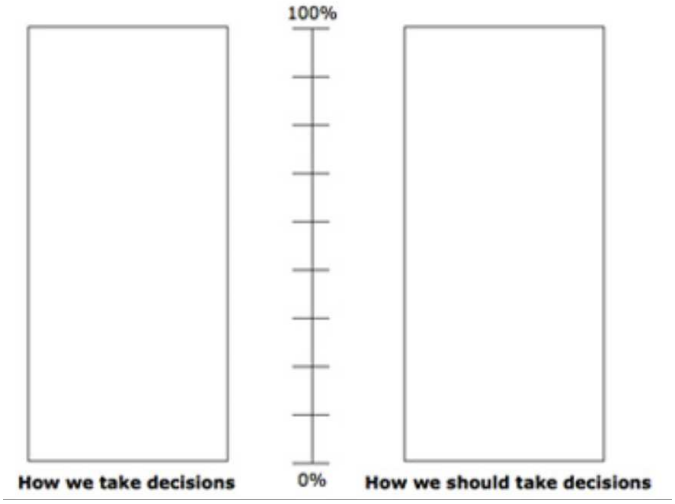
The table should be made as long as necessary, and after the discussion of the contents every team, a representative of each team should share their opinion with the rest of the participants. A definitive table should be done with the consensus of all the members.

6.4 STAGE 3

3.4.1 Workshop 3

Activity1: Processes and workflows are an important key factor in BIM adoption. That is why, before to continue with the process, reconsidering the processes having into account team collaboration is mandatory. For that, the outcomes from the activity 1, workshop 2 will be used to start developing and discussing the ideas.

Activity 2: The activity proposed at this stage is related with decision making, a very usual problem in every company. The activity consist in having two blank tables each one divided by 10, that represent the percentages. An example could be the tables below.



The target of the activity is to complete the two tables indicating and asking themselves: how we take decisions? And how we should take decisions? The activity is an exercise of reflexion of how they work and how they would like to work. The moderator can suggest some aspects related with that, as: authority rule, consensus, majority…

Having this analysis should be easy to find the way to change the way they make decisions.

Activity 3: As it was said previously, the realization of this activity is not essential in the process, but sometimes is highly recommended. For an organization as éBRICKhouse, it could be an opportunity to reinforce the trust and smooth work team issues.

6.5 STAGE 4

6.5.1 Workshop 4

For an organization as éBRICKhouse, a simulation of a real project is very interesting. Taking into account the number of students in the 2016 team, the design of a very simple project should be proposed.

The mediator, the same figure in activities before, can play the role of the client, asking for a "kennel". From this point the participants should start designing the work teams, and the first reunion with the client. It is advisable to keep at least two people to play the role of the observer. They should keep an eye on all the processes.

As a real project, all the steps and requirements should be followed. The design will be done with the BIM software and specifications about materials, security and construction should be detailed.

All the members should be critic with their work and the development of the activity can be paused if appear an issue that should be discussed.

CONCLUSIONS

The current situation of BIM in the AEC Industry has been analysed along the development of this dissertation. As a complex technology, BIM evolves very fast and every day new information appears. At the same time, due to its difficulty and the fragmented nature of the construction sector, it is tough to standardize and few documents exist to support BIM adoption in companies.

From this necessity of standardization comes up the idea of developing a framework for BIM implementation. In order to focus the investigation it was decided to centre in SME, because they are a pillar in the sector and the relations between workers are closer.

Based on findings, BIM adoption and implementation depends more on people and processes than on software and technology. This can be a reason why the process of BIM implementation in companies is so hard: more factors have influence, and these factors are variable depending on the teams and the individuals. At this point of the research, a proposal of the implementation methodology based on workshops seemed to be the most adequate, since it is perfect to control and anticipate behaviours. Workshops have another assets, too. They make all the members work together, engaging them to adopt BIM, making them to understand correctly the processes and avoiding resistance to change.

Analysing the difficulties that BIM has to face in the process of implementation, it appears that there are three main problems that concern to managers: collaboration issues, lack of training and difficulties in the management. The approach of the proposed framework was, not to avoid the problems, but face them and try to be more prepared to overcome the situation.

This way, mixing the workshop methodology and the intention to overcome the difficulties, the framework was developed, stablishing four stages each one of them dedicated to a subject: analysis, processes and roles, collaboration and test.

Although the stages have been settled, the framework does not pretend to be universal. In the contrary, the factors that have influence on the process are multiple, and the design of the framework should be personalised according to the company size, requirements, or type of projects, among others.

Along the development of the dissertation, it has been an intention to apply the framework to an existing organization. Nevertheless, as it has not been implemented, the behaviours and outcomes cannot be proved. From this point, it can be just make some indications for a future implementation. In one hand, have clear that the process of BIM adoption can be slow, and managers should be patient and let the process act at their own pace.

But what is really important is to have the capacity of continuously improvement, and for that, all the processes should be repeated, as a cycle, reconsidering the aspects that do not work as they should, and reformulating the policy and processes as necessary for the successful implementation.

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