

BIM training in Brazil

Preparing professionals for BIM adoption by public administration

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On May 2018 the Brazilian federal government published the Decree 9.377 setting a National Strategy for Information and Dissemination of Building Information Modelling - BIM to enable its adoption by public administration. This strategy has nine targets and among them the task of training professionals in BIM to support the demand that should be generated. A period between 2018 and 2021 has been planned to establish learning objectives and develop model disciplines, a process that, however, should not start from scratch because there are already some BIM training initiatives being performed in the country since the early 2000s. This paper has done an overview on this production highlighting some relevant conceptual contributions to this debate aiming to address challenges and possible ways to support the expected Architectural and Engineering courses restructuring.

Keywords: *BIM, Education, Architecture, Engineering and Construction*

INTRODUCTION:

On May 2018 the Brazilian federal government published the Decree 9.377 (Brasil, 2018) setting a National Strategy for Information and Dissemination of Building Information Modelling - BIM to enable the adoption of this new design and construction process by public administration.

This strategy has nine targets and among them the challenge to stimulate training professionals in BIM to support the demand that should be generated.

In order to achieving this goal, the official committee in charge to execute the National Strategy defined a Road Map for the next ten years, setting an agenda - which started on 2018 - with three phases and respective tasks according to each target.

Thus, for the BIM training target a period between 2018 and 2021 has been planned to establish learning objectives and develop model disciplines, a challenge that, however, should not start from scratch because there are already some BIM training initiatives being performed in the country since the early 2000s, when the sale of BIM software began.

In the very beginning of this process, software developers themselves started to teach how to use their software and, as the number of users started to grow up, several traditional software training companies also started to deliver specific courses about the best seller BIM software.

Despite they were not exactly BIM courses, since their focus was only on specific software features, they provided an undeniable contribution to the dis-

semination of BIM concepts, particularly about 3D modelling challenge rather than traditional 2D drawing activities.

However, when the Brazilian real estate market began to look for an efficient tool to improve the management of the construction process of its products, the understanding of BIM's resources was broadened and terms such as "quantification of components", "clash detection" and "4D construction planning", became part of the content sought by users interested in BIM training.

Then the opportunity to offer BIM courses opened to meet the emerging demand brought by the real estate market.

Initially the previously mentioned existing courses expanded their contents in order to meet this emerging demand but, quickly, it became clear that the knowledge demanded by BIM process goes far beyond the domain of the resources offered by BIM software and involves management and coordination skills of multidisciplinary teams. Features that, indeed, define a new profession: the BIM Manager.

Thus, a new demand started, and some postgraduate courses have been offered to professionals seeking to new challenges in their carrier or simply looking for upgrade their knowledge.

Then, there are already some examples that can be mentioned like the Master BIM Specialist course, offered by ISITEC, coordinated by PhD. Prof. Regina Coeli Ruschel, with 380 hours in two modules (ISITEC Innovation and Technology, 2018); the BIM postgraduate course offered by the Alpha Channel Technology Faculty, with 360 hours also in two modules (Alpha Channel Technology Faculty, 2018), both in São Paulo and the MBI-BIM of SENAI/CIMATEC with 650 hours in three modules in Bahia and the International Master BIM Manager - distance learning - offered by the University Centre of Brusque - UNIFEBE, in Santa Catarina, in partnership with ZIGGT - Global Institute of Technology, with six modules and different schedules, focused on aspects of management and design coordination using BIM.

In the same way the number of postgraduate

studies on BIM in Brazil has increased exponentially. In this regard, Ruschel & Lima (2018) identified the dissemination growth of BIM academic papers, comparing the Proceedings of two Brazilian reference events in this area, the ENTAC - National Meeting on Technology in the Built Environment 2016 and SBTIC - Brazilian Symposium on Information and Communication Technology in Construction 2017.

According to their analysis, the number of BIM papers in these Brazilian academic events doubles from one event to another, registering an increase in topics such as Facilities Management, the linkage among BIM, GIS and IoT and the growing interest in the introduction of BIM in the Architecture and Engineering undergraduate courses that seems to become the most challenger step: how to form new professionals under BIM culture?

Indeed, to teach new processes to those who have already acquired professional experience is quite different than form a new professional within new paradigms that, in fact, have not yet been completely understood by even those who are responsible for this training.

Focusing in this subject, Checcucci (2018) identified in Brazil, during the period between 2013 and 2017, four PhD thesis (Caixeta, 2013; Checcucci, 2014; Barison, 2015 and Romcy, 2017 - apud Checcucci, 2018) and eight MsC dissertations (Delatorre, 2014; Filho, 2014; Siqueira, 2017; Leal, 2018 - apud Checcucci, 2018) about teaching and learning on BIM with several different approaches, ranging from the absolute denial of the traditional design way, proposing its complete replacement by BIM to the perception that the collaborative and interdisciplinary practices of the BIM process can increase the teaching and learning of Architecture and Engineering.

A framework which demonstrates that this debate is still at the very beginning with very few established consensuses.

Indeed, BIM is not a simple replacement of a kind of software, it is a disruptive process that changes completely the traditional way of design and construction, anticipating and integrating in a collabora-

tive process several activities usually understood as separated tasks and it seems to be the starting point for this debate.

BIM VERSUS CURRENT BRAZILIAN ARCHITECTURAL AND ENGINEERING CURRICULA MATRIX

So, what is the real meaning of BIM?

According to Santos & Ramos (2017) the understanding of the real meaning of BIM is the first step to set up its potential uses and then to propose a strategy for its introduction in the regular Architecture and Engineering undergraduate courses.

In this regard, they propose to analyse each letter that compound the English acronyms BIM, examining their respective meanings once, even in English, there is no consensus on what BIM means.

Starting with the first letter B that refers to building, they argue that, etymologically, far beyond building itself, it means also the act of construction that, under the understanding of Alberti (2011, p. 231 - apud Santos & Ramos, 2017), it means to dispose the materials neatly and link them together with expertise.

Then, the sequence and organization of the construction process is the actual core of BIM.

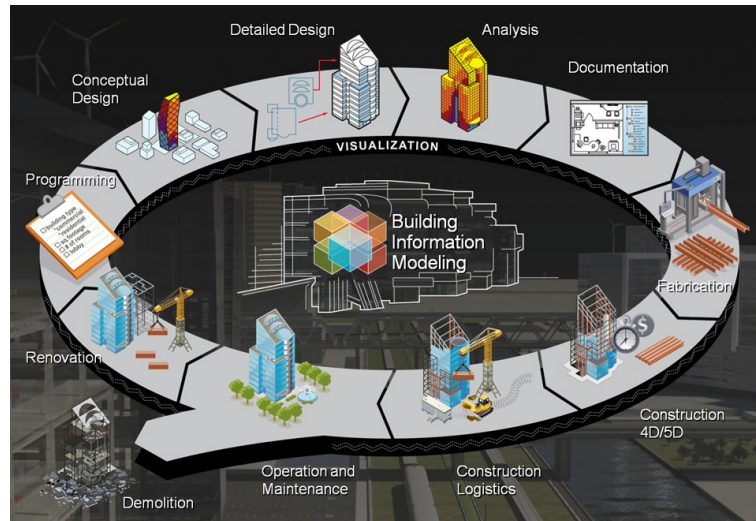
The second letter is I, meaning information that in BIM context should be understood as a communication process, where the information itself is sharply generated in order to be shared among the construction players.

The third letter is M, that should be understood as modelling, the action of a model construction which brings all the information about itself during its construction process, step by step. So, BIM does not refer to a finished model, but to the modelling process in which at any time any information can be extracted.

In their words, BIM should be understood as a construction communication and information process by a digital parametric simulation.

Thus, teaching BIM cannot be understood as a simple approach of a disciplinary content, once “sharing information” demands an interdisciplinary work that usually does not happen in the current structure with independent disciplines of Brazilian Architecture and Engineering undergraduate courses.

Figure 1
BIM Life Cycle
Source:
<http://buildipedia.com/aec-pros/design-news/the-daily-life-of-building-information-modeling-bim>



By the other hand, “sharing information” is inconsistent to the current dynamic of these courses based largely on expository classes in which the student is a mere receiver of the information transmitted to him by the teacher.

Actually, the proposal of BIM teaching on this Brazilian current undergraduate courses is challenger than it can be supposed because of their fragmented structure defined on the Education Ministry Act 2/2010 (Brasil, 2010) which divided their content in two different cores: the Foundation Knowledge Core, with disciplines as History of Arts and Social, Economic and Environment disciplines, and the Professional Knowledge Core, with Urbanism, Landscape and Architectural Design and, among others disciplines, “Informatic applied to Architecture” - in free translation - where BIM knowledge would be supposed included.

But the problem is that this discipline is still understood such as the teaching of software to help professional practices following the understanding of CADD - Computer Aided Design and Drafting like it was defined by the Education Ministry Act on the olds 1990's (Brasil, 1994) driving the discipline to representation skills rather than building model simulation as can be seen bellow:

“The study of “Informatics Applied to Architecture and Urbanism” covers the treatment systems information and representation of the object applied to architecture and urbanism, implementing the use of computer tools in the daily learning process” (BRASIL, 1994)

And even the attempt of Brazilian Association of Architecture Schools/National Education Council - ABEA-CNE in 2013 to broaden the content definition of this discipline adding the words “conception” and “expression” before representation didn't change the understanding that the main subject remains on “implementing the use of computer tools in the daily learning process”.

So, besides being very difficult to promote knowledge integration in this fragmented framework, the understanding that the digital technology

teaching in Architectural and Engineering courses is related to learn computer tools to draw the building components representation remains as an enormous barrier to BIM teaching and learning.

Thus, in that context, Santos & Ramos (2017) have no doubts: once BIM is a design and management platform that involves different activities since the architectural shappe conception to the organization of construction processes in the site it cannot be trained as an independent discipline. Maybe, it should evolve to become the Architecture and Engineering teaching and learning process itself.

DEFINING SKILL LEVELS ON BIM

Starting from another point of view, since the international practices, Barison & Santos (2011) proposed a gradual BIM implementation in traditional undergraduate courses, defining three skill levels, introductory, intermediary and advanced as it is showed below:

- Introductory level: the main goal is to develop modelling skills teaching BIM tools rather than CAD, which is no longer necessary to be known by the students. The proposal is to develop a basic building model, like a small residence, in order to explore basic modelling concepts and to understand the communication process of different kind of building information. They suggest teaching this content in graphic representation disciplines where architecture students can develop a house model from which they extract the information about primary components - doors, windows, furniture, etc - and since that they can refine the design, while engineering students may identify construction components of Structural or Mechanical, Electrical and Plumbing (MEP) areas, and work on them.
- Intermediary level: here the goal is to strengthen the BIM Modeler skills while some BIM Analyst skills are taught. The authors suggest that at this level the students background should include Design Fundamentals, Graph-

ics Representation, and BIM Concepts, and have experienced at least one BIM tool aiming to broaden this learning about other tools and 3D modelling advanced techniques studying building systems and exploring the BIM components families. An Integrated Design Studio and Building Technology courses is the ideal environment to this practice, where students could focus their studies in the building performance even using the Generated Design process, creating the parameters and formulas to explore more abstracts techniques. The authors also suggest that the BIM model should be constructed in teams where each student plays a specific role for a while and then is replaced, task by task, by another fellow among the students' team in order to avoid specific individual learning.

- Advanced level: the goal at this level is to develop some skills of a BIM Manager teaching techniques and processes such as interoperability concepts and BIM management tools for its implementation. Here it is necessary a student background on the use of main BIM tools, professional practice and construction techniques. The proposal is to develop a building model, about 5.000 to 15.000 square meters, maybe still in construction, working in a student team where the role of each one is chosen by the students themselves. At this level the teacher at the Integrated Design Studio or Interdisciplinary Design Studio plays the role of a BIM Manager. A faculty partnership with construction companies will be demanded and the building owner would play the role of a client together with designers, who provide feedback and takes part in the evaluations (Barison and Santos 2010b, Salazar, Vadney and Eccleston 2010, Holland et al. 2010 - apud Barison and Santos, 2011). The authors mention as a disadvantage that the faculty has less control over the projects and the students' experiences depending on

the availability and cooperation of the company professionals involved in that learning process.

Concluding their paper, the authors recognize that Problem Based Learning (PBL) and/or Project Based Learning (PBL) with teams of student are the best way to the BIM learning process and so they highlight the relevance of laboratory classes, workshop and lectures on BIM tools, the review of case studies and visits to companies and construction sites to give to the students a better understanding of the construction sequence.

To them, universities are very relevant in this transition to a new professional age with collaborative work where BIM process will play perhaps the most important role. But they still recognize the relevance of the professional market, suggesting that the academic world and the industry should do a partnership for the knowledge transfer.

Mentioning Lockley (2011) they say that maybe, in this very beginning of teaching and learning BIM process, this partnership between universities and professional market to promote collaborative thinking and setting up researches would be priority than the attempt to changes in the curriculum.

Studying the Brazilian scenery Ruschel; Andrade & Morais (2013) identified experience reports of BIM teaching in academic events of the following institutions: Universidade Federal de Alagoas (UFAL) (Andrade, 2007), Universidade Federal de São Carlos (UFSCar) (Serra; Ruschel; Andrade, 2011), Universidade Presbiteriana Mackensie (UPM) (Florio, 2007; Vincent, 2006), Centro Universitário Barão de Mauá (CBM) (Ruschel et al., 2011), Universidade Estadual de Campinas (UNICAMP) (Ruschel; Guimarães Filho, 2008; Ruschel et al., 2010).

Applying the three skill levels developed by Barison and Santos (2011), the authors found the result showed below:

According to the authors those didactic experiences show a diversity approach of BIM teaching cases in Brazil. They involve different courses (Architecture and Urbanism, and Civil Engineering), with

Evaluated Experiences	Competence Levels (Barrison and Santos, 2011)	Adressed Life Cycle Phases	Model	Products
UFAL (ANDRADE, 2007)	Introductory Level	Design	Modelling and Productivity	Parametric Modelling (architecture) and automatic documentation
CBM (RUSCHEL et al., 2011)	Introductory Level	Design	Modelling and Productivity	Parametric Modelling (architecture, structure and MEP) and automatic documentation
UPM (FLÓRIO, 2007)	Introductory Level	Design	Modelling and Productivity	Parametric Modelling (architecture and structure) and automatic documentation
UPM (VINCENT, 2006)	Intermediary Level	Design	Integration of models and applied use of the model	Parametric Modelling (architecture and structure) and automatic documentation quantitative and cost estimates
UFSCar (SERRA; RUSCHEL; ANDRADE, 2011)	Intermediary Level	Design and Construction	Modelling and Productivity and Integration of models and applied use of the model	Parametric Modelling automatic documentation and 4D
UNICAMP (RUSCHEL; GUIMARÃES FILHO, 2008)	Intermediary Level	Design and Construction	Integration of models and applied use of the model	Parametric Modelling (architecture and structure) automatic documentation, clash detection and 4D
UNICAMP (RUSCHEL et al., 2010)	Intermediary Level	Design and Construction	Integration of models and applied use of the model	Parametric Modelling (architecture, MEP, and structure) automatic documentation, clash detection and 4D

Table 1
 Classification of
 Brazilian teaching
 experiences of BIM
 according to the
 level of
 competence
 Source: Adapted
 from Ruschel;
 Andrade and
 Morais (2013, p.159)

different skill levels at different times (2006 to 2011). Most of them addresses the BIM teaching only in isolated disciplines except in some initiatives driven to integrate disciplines of architectural and structural design (Ruschel & Guimarães Filho, 2008; Ruschel et al., 2010).

In the authors words this framework shows that the implementing of BIM teaching process in Brazil remains in the level of introductory and intermediate competence and it is increasing gradually.

These experiences are mainly related to the parametric modelling of architectural design (with increasing documentation productivity, compatibilization and integration), 4D simulations and the generation of cost estimates. Even so, it is noted that these initiatives are not yet comprehensive. On the other hand, the most advanced experiences are scarce and can be classified only at the level of intermediate competence, leading to the second stage of BIM adoption.

None of these Brazilian experiences may characterize the training of BIM Manager - advanced level -, focusing precisely on the integration between management and BIM tools, simulations and 5D analysis and contractual discussions, such as Integrated Project Delivery - IPD.

But this scenery is not too much different from what happens in other countries. In this regard Checcucci & Amorim (2014), mentioning Becerik-Gerber, Gerber & Ku (2011), show that most of the Architecture and Engineering courses around the world began to offer some discipline that addresses the BIM paradigm between the years 2006 and 2009 but there is still no consensus on the best way or time to BIM teaching.

According to the report of Rebolj, Menzel & Dinevski (2008); Sacks & Barack (2010); Wong; Nadeem (2011) and Becerik-Gerber, Gerber & Ku (2011) (apud Checcucci & Amorim, 2014) there are several experiences already done aiming to adopt the 3D modelling in specific disciplines, mandatory or optional, covering a wide range of situations, such as: postgraduate courses; workshops (disciplinary or

multidisciplinary); during or at the final undergraduate course; etc. All of them facing the same challenges than Brazilian attempts.

So, what seems to be the major barriers everywhere is the integration of different disciplines and the collaboration among teachers to adopt the BIM paradigm by the current teaching and learning process.

However, still according to Checcucci & Amorim (2014) in Brazil other challenges can difficult BIM implementation as well such as: the demand for sophisticated and up-to-date machines and programs, lack of enough number of teachers with broad knowledge on BIM, lack of bibliography in Portuguese language and the difficult to insert the wide and complex BIM subject in the current curricular matrix of undergraduate courses.

Thus, according to the authors understanding the best way to implement BIM in Brazilian undergraduate course would be each course or institution seeks each own context, considering their resources and targets and so establishing a plan for this adoption, with steps and deadlines well defined.

In this regard, Checcucci (2014) points out some issues that should be considered, such as: people well trained in BIM skills, compatible infrastructure; target of skill level (basic, intermediate or advanced); focus on the objectives of BIM modelling; if applicable, a strategy to insert BIM in the curriculum; the method of teaching and learning adopted by the institution and the evaluation method.

According to the author, there are two possible strategies to BIM implementation in Architecture and Engineering undergraduate courses: new disciplines, which will increase the journey of teachers and students, or integrated insertion of the BIM process in different stages of student formation, involving a range of already existing disciplines.

In the context of the current Brazilian curricula of Architecture and Engineering, it is very difficult to insert more than two new disciplines which means that they probably will be focused on introductory contents.

Then, the authors suggest an integrated insertion of the content of modelling process in different disciplines, at different stages of the student graduation. They advise that this strategy presents the difficult to demand many teachers understanding the BIM concepts and so able to reach the goal of integration avoiding fragmented and insignificant learning.

However, this strategy enables for the students the possibility of different approaches and applications of BIM, with teachers from different areas and at various times of their formation providing a more solid learning.

To assist in this integrated adoption of BIM, Checucci (2014) developed a method of analysing the disciplines of the curricula of undergraduate courses in order to identify those who have the most affinity with this subject.

The next section presents and discusses this method.

THE DISCIPLINE ANALYSIS METHOD

Checucci (2014) believes that it is possible to implement a BIM adoption plan in an undergraduate course since the disciplines that are already regularly offered by them.

In this regard she proposes to map the existing curriculum matrix in order to identify in which disciplines subjects the desired content competences can be developed since the contents of each one classifying the disciplines in four categories, as following in a free translation author's words (Checucci, 2014, p.8):

1. the first one verifies the relation between the discipline and BIM, and classifies it as follows: (1) there is no interface with the theme; (2) there may be interface, depending on the focus the teacher gives to the discipline; and, (3) there is a clear interface with the BIM paradigm;
2. the second category evaluates whether the following contents of modelling can be worked out in the discipline: (1) life cycle of the building; (2) collaboration; (3) interoperability; (4) coordination of the modelling; (5)

geometric modelling three-dimensional; (6) parametrization; (7) orientation to objects; (8) semantics of the model; (9) display of the model; (10) numerical simulation and analysis;

3. the third category identifies which stages of the life of the building can be discussed: (1) study feasibility studies; (2) projection; (3) planning the construction; (4) construction; (5) use, which involves the operation and maintenance, and (6) demolition or requalification; finally,
4. The last category deepens into the design stage, noting that the following design disciplines interface with the curricular component: (1) architecture; (2) structure; (3) electric; (4) hydraulic, (5) air conditioning, and (6) other disciplines.

Thus, if a discipline is qualified in the option (2) of category (a), it means that there is no explicit interface between the discipline and BIM paradigm but some foundations of it may be inserted and practiced with the students. If the discipline is qualified in the option (3) of this category then there is a clearly interface with BIM paradigm and so, it must be identified in the category (b) which modelling content can be practiced with students and so on until it is possible to build a matrix of interfaces, possible contents, stage of building life cycle to be approached, design phase and which construction discipline will be studied.

The author did an interesting case study about the Engineering undergraduate course of Universidade Federal do Vale do São Francisco that can be accessed at <<https://periodicos.sbu.unicamp.br/ojs/index.php/parc/article/view/8634540/2461>> to better understand how this method works.

CONCLUSIONS

The Decree 9377/18 setting a National Strategy for Information and Dissemination of Building Information Modelling - BIM to enable the adoption of this new design and construction process by public adminis-

tration has done BIM a reality into the Brazilian construction chain imposing an agenda for all its players.

Among them are the institutions dedicated to the formation of new professionals such as Architects and Engineers that now need to adapt their traditional methods to this new reality.

On the one hand it is necessary to recycle the already graduated professionals through BIM post-graduate courses which is already happening.

By the other hand it is necessary to find the best way to form a new generation of professionals already inserted in the BIM culture of integrated and collaborative work, beyond the knowledge and domain of BIM tools, a task which has shown to be a great challenge because it involves several changes in terms of curricular structure, discipline contents and faculty knowledge.

To Santos & Ramos (2017), once BIM is a design and management platform that involves different activities since the architectural shape conception to the organization of construction processes in the site it cannot be trained as an independent discipline. Maybe, it should evolve to become the Architecture and Engineering teaching and learning process itself.

By the other hand, since international practices, Barison & Santos (2011) propose a gradual implementation of BIM in traditional undergraduate courses, defining three levels of skills: introductory, intermediate and advanced that should support the courses restructuring, according to each one of their guidelines.

To them, Problem Based Learning (PBL) and/or Project Based Learning (PBL) with teams of students are the best way to the BIM learning process and they highlight the relevance of laboratory classes, workshop and lectures on BIM tools, the review of case studies and visits to companies and construction sites to give to the students a better understanding of the construction sequence.

The authors really believe that, although universities are very relevant in this transition to a new professional age with collaborative work the relevance of the professional market is as well significative, sug-

gesting that at this time the academic world and the construction industry should do a partnership for the knowledge transfer.

Applying the three skill levels developed by Barison & Santos (2011) to the Brazilian didactic scenery Ruschel; Andrade and Moraes (2013, p.159) found several experiences that show a diversity approach of BIM teaching cases in Brazil involving different courses (Architecture and Urbanism, and Civil Engineering), with different skill levels at different times (2006 to 2011).

However, most of them addressing the BIM teaching only in isolated disciplines except in some scarce initiatives (Ruschel & Guimarães Filho, 2008; Ruschel et al., 2010). Thus, they can only be classified at the level of intermediate skill, leading to the second stage of BIM adoption.

But, to Checcucci & Amorim (2014) this scenery is not too much different from what happens in other countries where most of the Architecture and Engineering courses began to offer some disciplines that address the BIM paradigm between the years 2006 and 2009 but there is still no consensus on the best way or time to BIM teaching (Becerik-Gerber, Gerber & Ku, 2011 - appud Checcucci & Amorim, 2014).

However, they recognize that in Brazil other challenges can difficult BIM implementation as well as the cost of the necessary updated infrastructure and enough number of teachers with broad knowledge on BIM, thus, they understand that the best way to implement BIM in Brazilian undergraduate courses would be each institution seeks each own context and respective difficulties.

In this regard, Checcucci (2014) developed a method for analysing curriculum disciplines in undergraduate courses in order to identify those who have a greater affinity with this subject and, thus, to build a matrix of affinities that can guide the restructuring of these courses.

She applied her method to evaluate the Engineering undergraduate course of Universidade Federal do Vale do São Francisco and since the result did a proposal of some changes in its curricular matrix,

although not yet validated.

However, as demonstrated, at the same time that the current Architecture and Engineering courses have the challenge to promoting important changes in the training of the new generations of design professionals, this process will not happen from scratch, since there is already a reasonable thinking process on this theme that, in order to evolve, now needs to focus on practical experiences that can validate the theoretical framework that has been already elaborated.

For this purpose, certainly, it will be necessary to develop metrics that allow an objective evaluation of the results of these attempts.

In this sense, the partnership between the academic world and the professional market, suggested by Barison & Santos (2011), may become very important, since it would allow to identify which of these experiences have been able to meet, in fact, the competences required by the professional practice on BIM.

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