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Understanding the Impact and Necessity of Building Information Modelling (BIM) Tools for Efficient Design and Construction

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Article Information	ABSTRACT

The development of technology in recent years has been growing exponentially. Not only has it majorly revolutionized many fields like science, mathematics, and entertainment, but it has also made a huge influence on architectural trends and construction techniques. This research focuses on the necessity of digital aid, specifically Building Information Modelling (BIM) tools and how they have made an impact on the process of designing and planning structures in India. A comparative analysis is done between the syllabi of Architectural colleges across the whole nation of India, and some differences are identified regarding the teaching of BIM tools and applications during the course. The BIM syllabi is analysed further in the context of its necessity and use in professional architects' practice. BIM tools do not only help design and construction teams to work in a better and more efficient way, but the tools also allow them to utilize the data that they produce during the process, to benefit operations and various other tasks. Therefore, BIM mandates are rapidly increasing across the globe, as the years go by. The emergence of these tools has definitely made a positive influence on people's proficiency at design, planning and construction phases, but it also has a few downsides to it that are discussed further in this paper.

KEYWORDS: BIM tools, architecture, development, technology, technological convenience

1. INTRODUCTION

BIM, known as Building Information Modelling, has been an upcoming form of technology in the field of architecture, engineering, and the construction industry, over the past couple of years. It has become the very foundation of digital transformation in these areas, without which, planning seems like a very difficult and tedious task. Due to this convenience, it has started to become a necessity for people, specifically those in the previously mentioned areas of occupation, to be familiar with. Many professionals believe that BIM is the future of design and construction, which is why its training and practice are a necessity, too.

Some of the most popularly used BIM tools are as follows (in no specific order)-

1. Revit
2. AutoCAD
3. ArchiCAD
4. Navisworks
5. Aurora
6. pvDesign
7. MicroSation
8. Civil3D
9. VectorWorks Architect
10. Tekla Structures

These software tools provide an easier and more helpful approach to visualize, develop shapes and forms, and experiment with 3-D structures and objects. It aids in efficiently and precisely analyzing and checking the working of an object, with in-built simulation features with perfect accuracy, that one can keep editing and altering in minimal time, before

sending it out for manufacturing, construction, or execution.

Some of the many significant benefits and advantages of using BIM tools while designing in architecture are- BIM incorporates multi-disciplinary data to create detailed and accurate digital representations and illustrations that are managed in an open cloud platform for real-time collaboration. Using BIM gives you greater visibility, more sustainable options, better decision-making, and cost savings on certain types of projects; for example, AEC (Architectural Engineering and Construction) projects.

According to the statistics provided by United Nations in 2019, it is estimated that the world population would be around 9.7 billion in the year 2050. That is only a little more than 25 years and a population of 2 billion more than the current population (as of 2022). This calls for better, organized town and city planning that is also energy and climate efficient, not just as a means to keep up with the current trends and global demand, but to also help create spaces that are resilient and smarter, as well.

This research aims at finding the gap between training offered in BIM tools and softwares and the actual implementation and execution of it in the profession of Architecture. To carry out this research, a comparative survey is done across universities in India to identify which universities offer training in BIM technology and how the training makes a difference during their practice as an architect, after graduation.

2. LITERATURE REVIEW

According to many BIM software users, the development of BIM is revolutionizing the way projects are executed across industries, adding intelligence, efficiency and little to no room for error– for making the best outcomes possible.

BIM tools help to fruitfully use the processes of analysis and evaluation programs during the progress of design. However, the current approach towards analysis and evaluation of design requires the making of a separate building model for each kind of assessment. This mainly involves using a BIM tool to create the data for a certain type of analysis to obtain design feedback. When dealing with multiple analyses, this process becomes time consuming, and largely reduces the benefits of BIM, which defies its whole purpose [Sanguinetti et al., 2012].

Several schools and institutes are using BIM for teaching architecture and civil/ structural engineering. Most of them have only introduced BIM in one subject and a few are trying interdisciplinary or collaboration between subjects [Barison, 2012]. The main approach is to introduce BIM in design studios itself. Another approach is to teach tools and BIM concepts in a particular subject, which may be further integrated with the syllabus and in the design studios. [Barison and Santos, 2010].

As BIM has become a standard in the AEC industry, it is extremely essential that these programs train the future construction professionals in the potential and benefits of BIM technology as lack of adequate training has been one of the biggest challenges of the industry to progress into the BIM era. [Yilei Huang, 2018] Although several studies have suggested that integrating BIM into existing subjects is the most feasible approach, comprehensive frameworks have not been created that are able to provide a holistic coverage of BIM in the curriculum. [Yilei Huang, 2018].

BIM, for now, seems very likely to be the trend of the future [Gokuc and Arditi, 2017]. Three models are proposed that investigate whether the fit between BIM technology and (1) design tasks, (2) the organizational competence of the design firm, and (3) designer competence affect the performance of the design firm [Gokuc and Arditi; 2017].

Despite the drawback of technology adoption facing a lot of resistance, the improvements made and benefits obtained from adopting the new technology are typically worth the efforts. According to Kaner et al. (2008), the implementation of formal BIM training for personnel on a project resulted in a productivity increase of over 600%. The study conclusively affirms that BIM undeniably enhances the quality of precast engineering designs and fabrications, while also ensuring error-free construction processes. Additionally, BIM significantly reduces the time and effort required for evaluating drawings and plans. [Sahil, 2016]. BIM implementation for renovation is relatively less developed. The recommended methods include as-built modeling and laser scanning, but these are often not detailed. Requirements for BIM in renovation projects vary. [Sacks, Gurevich, Shrestha; 2016]. Project participants' competence in BIM is vital for harnessing its benefits. Construction clients must prioritize ensuring a minimum level of ability among participants. [Barison and Santos, 2011].

According to an article by Zigurat Global Institute of Technology (2022), it is said that BIM still has a long way to go in terms of usage and application in India, but it is getting there; and in the next 10 – 20 years, when the population of India is estimated to surpass

that of China, BIM technology will be forced to expand across the country due to the inevitable need for more infrastructure, educational spaces, and social housing; which will automatically demand for qualified professionals and students for its training.

The literature emphasizes that the training of future professionals is essential for greater efficiency during design and construction processes. It also reveals that there is a gap between the training of BIM tools in the curriculum and its demand and requirement in the profession. Therefore, this study is significant to identify the gap between training and application in the Indian scenario.

3. METHDOLOGY

The initial stage of this research consisted of collecting necessary data regarding the syllabi of universities across India and comparing them with each other to obtain a pattern of training BIM tools in the degree and implementation of it during professional practice. This is further correlated with the extent to which these BIM tools are actually used by professionals in their designs and planning processes and to finally investigate the necessity of BIM training and whether it really makes a difference in the efficiency of the output as opposed to not using these tools.

A survey was conducted in the form of two questionnaires via Google Forms, one for architectural professors and tutors, the other for practicing architects, in which they were asked if any BIM-related training was provided to them when they were pursuing their B. Arch degree, if they are aware of BIM softwares, if they frequently make good use of it in their designs, if they offer BIM lessons to students and many more questions that could give a clear and realistic idea of the current trends and situation in the technology and to also be able to understand the professionals' unfiltered and unbiased opinions about it. The focus area of this research was the state of Maharashtra, India, which is where the questionnaires were administered, and the answers were obtained only from those architects who had studied in any university in the state, regardless of the state or country in which they are currently practicing.

After the necessary data was collected, it was analyzed and processed after which certain patterns and gaps were identified, that further pointed to a reasonable conclusion. For the analysis, every single response was reviewed thoroughly, and a comparative study was done to find out which institutes and universities have the most engagement with the BIM technology and to what extent they are used while making designs and executing them on-site. This survey gave a head-start and defined the next steps to take the research ahead to understand the real-life scenario of the usage and familiarity of the technology in different parts of the state.

4. DATA COLLECTION

A sufficient amount of data and information was collected that was necessary for the research to progress, like previously done research papers relevant to the topic, literature reviews, book reviews, article findings, graphical diagrams and online searches pertaining to certain aspects of the BIM technology and explaining them in concise and simple ways.

In the first stage of the research, A comparative study was done in which the architectural syllabi for years 1 to 5 of the B. Arch degree were obtained from across India and a list of similarities and differences was made to observe gaps and links between the curriculum of different universities for the course (See Table No. 1).

Stage 2 of the data collection process consisted of going deeper into understanding the technology of BIM and researching its benefits, use and application points, its scope for the future, its development and upcoming and its downsides, with the questionnaire survey.

Table 1. Differences in Curricula

Sr. No.	Region of India	University	Observations
1.	West	Mumbai University	● No computer-aided individual subject as a part of curriculum. ● Computer-based learning offered as an elective. ● Representation and Arch. Theory offered as individual mandatory subjects. ● No mandatory internship in 5th (final) year.
2.	West	Rajasthan University	● Computer-aided subject introduced in the 1st year. ● Many extra-curricular activities offered as electives. ● Internship not mandatory as a part of the course.
3.	South	Hyderabad	● Computer software training

		Universi ty	introduced in semester 4 (Year 2). ● Internship mandatory as a part of the course.
4.	West	Pune Universi ty	● Computer based software training introduced in the first half of 2nd year. ● Advanced software training offered as electives in 3rd and 4th years. ● Internship mandatory in the final year (9th semester).
5.	North	Jamia Millia, New Delhi	● Computer-based software training offered from 1st year onwards. ● Computer-aided interior design taught as an individual mandatory subject in almost all semesters. ● Internship included as a part of the course.
6.	East	Jadavpur Universi ty, Calcutta	● Computer-based training offered from the third semester (2nd year). ● Computer aid used in design studios. ● Practical Training/ Internship of 24 weeks mandatory as a part of syllabus in 7th semester (4th year).

5. DATA ANALYSIS

Through the vigorous interviews, questionnaires, and information collection, it was found that to many people (including novice trainees, young architects, and experienced professionals), BIM still, for the most part, remains to be an unfamiliar technology that many surprisingly have not even heard about or do not know the meaning and purpose of. When it comes to 2D drawing-creating softwares, like AutoCAD, or ArchiCAD, the majority of the architects are fully familiar and well-acquainted with its interfaces, and use them on a daily basis for creating plans, sections, elevations and other 2D illustrations and diagrams. The problem mostly lies when it comes to dealing with 3D models and using simulations to analyze the physical behaviour and sustainability of a certain mechanism or structure.

Through the comparative study of the architectural syllabi, it was observed that most of the universities in India have a similar curriculum and only a few universities and institutes have prominent and noticeable differences in them. (See Table No. 1). Most of the colleges and universities offer computer-aided training from the first or the second year, except Mumbai University, which doesn't have a separate mandatory subject for it and is offered as an elective. Some of the universities include a semester-long internship mandatorily as a part of their curriculum, whereas some don't.

From Table No. 1, it is observed that all of these universities offer computer-based software training some time within the 5-year course. Rajasthan University and Jamia Millia have made it mandatory to teach digital tools since the 1st year of their B. Arch course. Other universities introduce the subjects at a later stage- in the second or third year. Mumbai University does not provide mandatory lessons in digital softwares as a part of their curriculum, although they can be taught as integrated lessons with the other subjects.

Since this technology emerged quite suddenly with the revolution of other digital devices, its development wasn't observed to be an organised one and quite literally, took its own path. Despite this, it still has not fully developed and is still yet to reach and be introduced in economically weaker parts of India.

6. RESULTS AND DISCUSSIONS

After conducting the surveys and sending out the questionnaires to architects and tutors, the responses that were obtained were thoroughly observed and analysed. Around 30 responses were received for the questionnaire that was meant to be filled by professionals and practicing architects, and 15 responses from architectural professors and tutors.

In the former questionnaire, the respondents were first asked if they were aware of BIM tools, to which 83% of people answered "Yes" (See Diagram No. 1).

The universities the respondents studied their B. Arch degrees from were Pune University, Mumbai University, and Goa University. 75% of the respondents had received training of BIM softwares from the institute they studied their B. Arch degree. Majority of the people believe that BIM tools are necessary to be used during design and construction

processes and believe that BIM is the future. Almost half of them had not pursued a master's degree, which means most of their training in BIM was either done during their B.Arch degree or they learned it by themselves after graduation. Contradictorily, almost half of the respondents said they do not use BIM tools in their design processes which was a surprising observation. Those who do use the tools said they mostly use it in their design process (40%), implementation (30%), execution/construction (10%), estimation (10%), and 60% said they use it for all of these processes.

For the questions about hiring employees and interns, 80% of the respondents said that they look for interns and employees that are skilled and well-equipped with the knowledge of BIM softwares, like Revit and ArchiCAD. In case an employee is not very skilled in these softwares, 60% of architectural firms provide at least basic and beginner-level lessons to them.

In the second survey for professors and tutors, all of them had pursued a master's degree from either Mumbai University or SPPU (Savitribai Phule Pune University). 80% of them teach in institutes that currently offer training in BIM, either as a part of the curriculum or as an elective. The respondents said that BIM is the need of the hour, and its training is necessary for securing a good internship and later finding better job opportunities, since that is one of the biggest requirements of architectural offices for appointing their employees. (See Diagram No. 1- for above information)

The pie charts in blue are those obtained from Form No. 1 (for practicing architects) and those in orange are obtained from Form No. 2 (for professors and tutors).
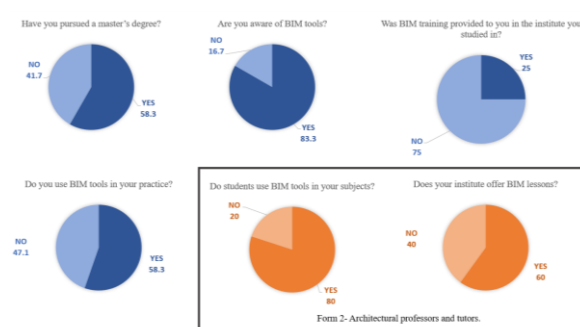

Fig. 1. Pie representations of responses obtained from surveys. (Source- Author)

7. CONCLUSIONS

From the research, the main observation made was that a good amount of institutes in Maharashtra currently offer training in BIM softwares to their students, which is a positive change, because this

reveals that it only means that there is going be progress in the technology and perhaps in the next 20 years, we would be able to see BIM tools being used everywhere necessary- in architecture, construction and engineering.

Internships should be made mandatory in the curriculum to enable students to implement the skills they learned during the course and get an experience of the professional work environment.

Despite the fact that most present-day practicing architects did not receive training in BIM when they were studying in architectural institutes, they taught themselves as required to keep up with the current trends and technological innovations. This shows that BIM softwares are not extremely difficult to learn and they can be self-taught, with the right resources. But it is time-consuming. Therefore, it is best if one learns it during the time they pursue their degree and integrate it with the other subjects they study.
If these tools are taught from a very early stage of a person's professional journey (from the first year of their undergraduate program), it will be very beneficial for the students to learn and implement these tools early-on and help expand their ability to learn and grasp concepts quickly and easily.

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