“Development of a Framework to Support Embedding BIM within Undergraduate Architectural Programmes in Lebanon ”

The University of Salford
School of the Built Environment
PhD thesis

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23 October 2018

Ali Rachid

Dear Ali,

RE: ETHICS APPLICATION STR1819-02: Development of a Framework to Support Embedding Building Information Modelling within Undergraduate Architecture Programmes.

Based on the information you provided, I am pleased to inform you that your application STR1819-02 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Dr Anthony Higham
Chair of the Science & Technology Research Ethics Panel

ACKNOWLEDGEMENT

I am so proud and content to present you my thesis that was the result of so much hard work and dedication. The final year of the research was very challenging to overcome, whilst the economic crisis that occurred in my country, Lebanon, and the global COVID-19 pandemic; both created further unexpected difficulties. In the end, what matters the most is that I finally made it here.

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I must express my profound gratitude to my beloved family for providing me with unfailing support and encouragement throughout my years of study up until today. This accomplishment would not have been possible without them. I encourage every person to go after their dreams and be lifelong learners because education and research are a never-ending journey.

Thank you.

ABBREVIATION

2D: BIM Dimensions - Two Dimension BIM

3D: BIM Dimensions - Three Dimension BIM

4D: BIM Dimensions - Four Dimension BIM

5D: BIM Dimensions - Five Dimension BIM

6D: BIM Dimensions - Six Dimension BIM

7D: BIM Dimensions - Seven Dimension BIM

ABET: Accreditation Board for Engineering and Technology in The United States

ACCE: The Accreditation Council for Continuing Education in The United States

AEC: Architecture, Engineering and Construction

AECOO: Architecture, Engineering, Construction and Owner Operator

ARB: Architects Registration Board in the United Kingdom

BAF: BIM Academic Forum

BIM: Building Information Modelling

CAD: Computer Aided Design

CDE: Common Data Environment

CIFE: Center for Integrated Facility Engineering

CNC: Computer Numerical Control

CO2: Carbon Dioxide

DSR: Design Science Research

eQUEST: The Quick Energy Simulation Tool

FM: Facility Management

GC: General Criteria

GCC: Gulf Cooperation Council

GSL: Government Soft Landings

HM: Her Majesty

IESVE: Integrated Environmental Solutions Virtual Environment

Int: Interviewee

IPD: Integrated Project Delivery

MEA: Middle East and African Countries

MEP: Mechanical, Electrical and Plumbing

MOOC: Massive Open Online Courses

NBS: National Building Specification

NIBS: National Institute of Building Science

pBIM: Proprietary BIM

PBL: Problem Based Learning

POD: Point of Departure

POE: Post occupancy evaluation

QAA: Quality Assurance Agency

RIBA: Royal Institute of British Architects

UK: United Kingdom

US: United States

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ABSTRACT

The increasing needs and demands of humans have at all times been translated into changes and evolution. And with the rise of huge and complex projects, the AEC industry has adopted systems and technologies that promote the fast delivery of the market's requirements and better results using the most appropriate and efficient method of today's systems.

BIM is one of the approaches that changed the AEC industry. The concept of BIM is not new, yet its rate of implementation is variable in different regions. Several countries have witnessed an increase in BIM use in the past years (NBS, 2019, McGraw-Hill Construction, 2012, Jung and Lee, 2015) and this is due to low productivity, poor functionality, design errors, and waste (Deutsch, 2011, Smith and Tardif, 2009) and how this system can be a part of the solution.

The introduction of the BIM approach within the AEC industry necessitates the acquisition of new skills. Building the future starts from the fresh graduates of the academic institutions. Thus, it is essential for graduates to be equipped with these new skills. This calls for a realignment of the architectural and engineering curriculums which are deemed necessary to ensure a full successful implementation of the system. For this purpose, it is important to enhance the learning process that shall be reflected in knowledge, skills, management, and presentation techniques of architectural projects of different scales and types.

Different approaches have been taken to implement BIM, from standalone to integrated courses, yet there is no clear defined method to implement BIM within the whole curriculum in Lebanon. This leads to the formulation of a gap between graduates' outcomes and the Lebanese industry demands.

The aim of this research is to create a structured framework to implement BIM within architectural education in Lebanon without replacing the traditional learning architectural method.

The outcomes of this research aim to support Lebanese universities in specific, and worldwide universities in general, with a guideline for effective and flexible implementation of BIM within the 5-year architectural engineering program.

This research uses semi-structured interviews with professionals, educators, and students. The results of the interviews reflected by the researcher lead to a framework proposal to be implemented in the curriculum. Therefore, market demands are served. The designed framework is validated using a design science methodology and peer review from the industry and academia. This adds value at the university level, readjusts the learning outcomes in parallel to the industry's demands, reduces BIM adoption costs, achieves the learning objectives, and expands the knowledge and understanding of BIM to become one integrated part of the architectural curriculum as a first stage and in the practical field as a second stage.

Chapter 1 **RESEARCH INTRODUCTION**

The following chapter introduces the research topic in response to existing global issues. It discusses the motivation driving the researcher with the formulated research question, the aims set, and the identified objectives. The scope of this study and the sequence of work represented in the methodology are highlighted. This chapter sheds light on the value of this research in the contribution and the limitations of this study. The chapter ends by outlining the structure of this research, providing the planned steps, and highlighting the main topics of each chapter.

1.1. Introduction

1.1.1. Observations: BIM as future solution

BIM stands out as a solution to multiple problems, one of which is the environment through the benefits BIM offers in predicting and controlling the delivery conditions (NBS, 2018). Apart from modelling, BIM can perform various analyses that aid in environmental studies. Different options can be assessed in order to adopt the ultimate option that can respond to the climate conditions and the user requirements.

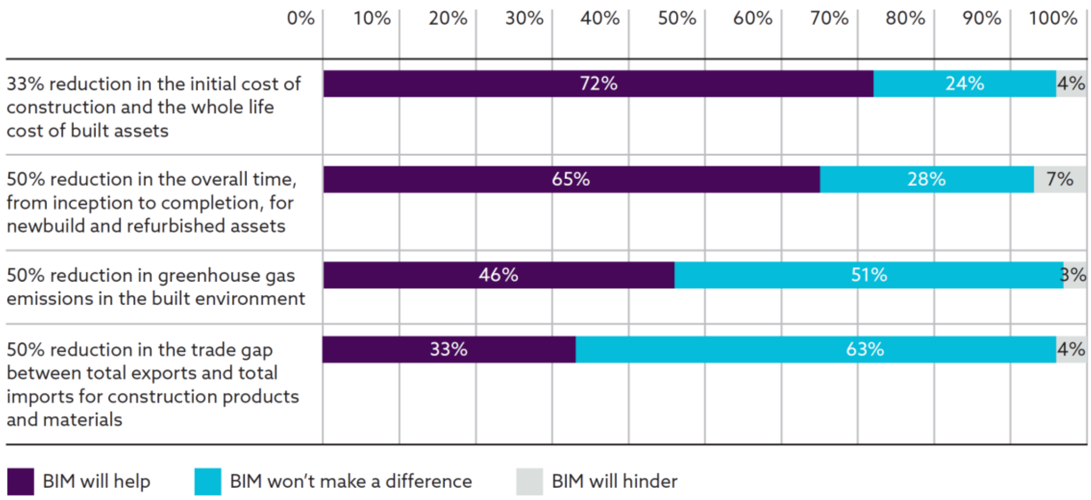


Figure 1-1 Benefits of BIM (NBS Report 2018)

BIM allows engineers to import data into the building model, such as locating the project geographically and providing the existing climate parameters. On a further level, the model can be updated and re-oriented to adapt to environmental conditions and attain efficiency in saving resources (Mousa et al., 2016). The capability of BIM to analyze the building mass with scientific calculations and apply optimized solutions to its elements shall ensure the reduction in the consumption of different energy sources. For subcontractors, BIM can additionally be employed in the reduction of waste and the integration of shipments in order to lessen carbon emissions (Krygiel & Nies 2008).

BIM acts as one powerful collaborative tool that unifies the communication language between all the project's stakeholders on one single model. The national BIM report issued in 2018 has concluded that the majority of experts believe that BIM use implied several benefits (Malleson, 2018). The survey of the NBS BIM allows the assessment of how BIM success was seen.

At a further level, the operation and maintenance of the building can contribute to the increase in carbon emissions. The poor maintenance of the building shall cause a rise in the consumption of energy and therefore increase CO2 emissions (Chen et al., 2013). Research proves that the use of BIM technology improves the facility management (FM) of the building, which promotes better operation and less energy consumption (Motawa et al., 2012).

1.1.2. The Process: The implementation of BIM

BIM is one powerful tool that was introduced greatly to different projects worldwide. BIM adoption recorded significant growth in various parts of the world in previous years (McGraw-Hill Construction, 2012; NBS, 2016. Jung, and Lee, 2015). In the case of the UK, awareness and use of BIM have increased from 13% in 2011 to 69% in 2019 (NBS, 2016). BIM adoption approach has been proven to be successful in addressing issues related to low productivity, poor functionality, rework, and waste at different project and organizational levels (Deutsch, 2011. Smith and Tardif, 2009).

Similar to the UK example, the Municipality of Dubai was the first public authority in the Middle East to request the use of BIM for large-scale projects (Lee et al., 2013). In Kuwait, reports reveal that the implementation of BIM turned out to be effective where it has mitigated project risks, improved communication and collaboration between different stakeholders, which offers a transparent monitoring throughout the whole project's lifecycle (Gerges et al., 2016.).

In 2017, Gerges et al concluded that adoption of BIM in the Middle East region is increasing and highly implemented within the construction phase. Mehranet 2016 reported that among the Middle Eastern countries the United Arab Emirates was leading the implementation process in 2016 and this is a result of the early mandate from the government in 2013.

The first target in BIM implementation is achieved when company managing directors, board members, and shareholders fully understand the challenges of BIM, its advantages, and impacts. The acceptance of BIM and the willingness to change the long-term working strategy of the company from the existing form to an integrated one that invests in the BIM business and work model. The next target is related to managers at the middle level, such as directors, head of departments and technical managers. These are responsible for managing and implementing the change in their respective departments while addressing challenges and promoting new opportunities on the short-term targets. The final target is to introduce BIM to senior, intermediate, and junior engineers and assign BIM teams. The implementation of BIM starts on this level with training the assigned engineers, which necessitates in the first place the presence of compatible computers. Each resource is trained to use BIM from the pre-concept stage, all through the detailed development of the project, and the operation after its construction.

Nevertheless, the implementation of BIM remains limited since it is still not adopted in many academic curriculums. This formulates a critical problem that hinders BIM effective implementation at the professional levels.

1.1.3. Problem and Gaps: Gap between Educational level and Industry Needs

While new innovations are being introduced within the construction industry, students and professionals need to stay updated with these novel technologies. This necessitates the acquirement of new skills that need to be incorporated starting from undergraduate studies to be reflected later in the professional field.

Like any new language, BIM is a communication tool that represents a common language in the educational and construction industries. For several years, the transition from the educational level of the freshly graduated to the industry requirements has failed to meet the demand of the field because the adoption of new technologies was not involved within the educational phase of these graduates (Almutiri, 2016). Hence, the outcome does not allow graduates to be fully prepared for recruitment opportunities.

In Lebanon, the process of implementation within the academia is slow where awareness about BIM importance and advantages is still low and limited, especially with the lack of any motivational acts by the public sector. The key to motivating the adoption of BIM within the curriculum of architectural engineering is the recognition of BIM's importance and advantages in the industry. Hence, its requirement in the educational program becomes inevitable in different countries.

Besides the lack of resources that aim to guide the implementation of BIM within the educational sector (MacDonald & Mills, 2013; Merschbrock et al. 2018), Mandhar et al. 2013 represented in previous research the gaps that prohibit the full integration within the educational sector are concerned with problems such as:

- the lack of a defined BIM method implementation
- the lack of BIM implementation framework,
- the lack of BIM framework evaluation in undergraduate problems
- the lack of knowledge regarding BIM capabilities in the architectural education sector

The wide image of BIM implementation is represented by the parallel use of BIM between all disciplines (architecture, structure, electrical, mechanical, quantity surveying) and all parties (contractor, subcontractors and the client). This, in turn, is reflected in the educational challenge program, where the challenge starts from instructing BIM at early stages of the curriculum in the process of developing the necessary skills for the student to attain a professional level by the year of graduation prior to employment.

1.2. Research Question

What is the effective and most appropriate method to implement BIM education within the undergraduate architectural curriculum?

1.3. Research Aim

'The aim of this research is to develop a framework that supports the adoption of BIM in undergraduate architectural programs and curricula in Lebanon.'

1.4. Research Objectives

To achieve this aim, the following objectives have been determined:

1. To identify the BIM best practice and capabilities and how it can assist in achieving the learning outcome in architectural education.
2. To investigate the current BIM implementation methods and approaches within academia.
3. To investigate the current BIM implementation situation within the industry and academia in Lebanon.
4. To develop a framework for integrating BIM within the undergraduate architectural programs aligned with the current learning objectives.

5. To validate the framework through peer review and educational and professional opinion.

1.5. Scope of Study

The scope of the performed study took place for a period of 3 years. The final output of the study is a developed framework that ought to facilitate the implementation of the building information modeling concept within the architectural curriculum of a design studio-based program in Lebanon.

The formulation of the framework is based on two sources to draw up the guidelines. The first source is from the previous reports of the other successful implementation trials worldwide. It is worth noting that the short time of study implies the extraction of this information from the literature review that focuses on previous successful cases of implementation, especially within the UK as a leader in the implementation of BIM within the industrial and educational sectors. The second source will be based on the results and points of view received during the semi-structured interviews performed in the Lebanese educational sector with professionals and experts, in addition to professional educators across the ME region and the UK. The output shall draw guidelines that ensure the successful implementation of BIM in architectural education.

1.6. Research Methodology

This research aims to develop a framework that supports the adoption of BIM in undergraduate architectural programs and curriculums in Lebanon. As the objective of the research is to make a transition from theories about BIM to a practical BIM implementation framework, the followed method is the CIFE "Horseshoe" (Kunz et al., 2007) for transitional research:

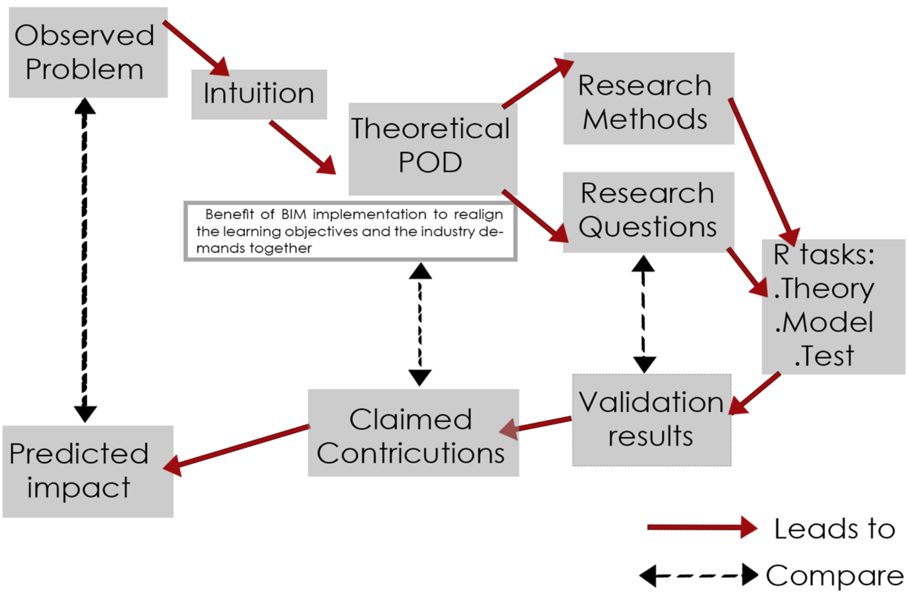


Figure 1-2 The CIFE Horseshoe method of Transitional research
(Source: Based on Kunz et al., 2007 model)

Figure 1-2 summarizes the transitional process in the methodology. The starting point of the research was the observed problem by which intuition acted as a theoretical point of departure. In this research, the observed problem emerged from the existing gap between the university outcomes and the industry demands which are not fully compatible, as explained in the first part of the introduction. The starting point of this research was the necessity for architecture students to understand BIM through the development of a structured methodology. Its aim is to present an endpoint of a well-defined framework for the implementation of BIM in the architectural educational environment.

To achieve this transition , the research approach was the design science research (DSR) because it enables the researcher to create an validated artifact outcome; which is in this research's case the framework implementation of BIM within the curriculum in Lebanon. The generated theory determined the proper research methods and questions which took the research to the process of theory, modeling, and testing. Next, the outcomes of the research tasks are validated in comparison with the initial research questions. This, in turn, led to claimed contributions that were compared to the theoretical point of departure as explained in chapter 8 of this research.

The data collection process was mainly concerned with the semi-structured interviews with professional academics and students that were selected from accredited institutions in the UK and Middle East regions. The estimated time for the interview was 1 hour and it was performed in person or via social interfaces based on the participant's preference.

When discussing the interviews, it was necessary to understand how the students were dealing with BIM technology and how far they can relate to the topic. The open discussions were performed through invitations for students at their university, done in person or via social interfaces. The analysis of the collected data was performed manually using thematic data analysis, which helped in identifying a common pattern in the answers related to the research questions to come up with the suggested framework to be implemented.

After the framework development, discussions with expert educators and professionals followed for the purpose of the validation of the suggested framework. The feedback received from the validation process resulted in minor modifications that were made to develop the framework further as a final result for the artifact of this research.

1.7. Contribution to Knowledge

The approach adopted in this research is design science research. Once dealing with the contribution to knowledge, the data collection shall assist in designing the artifacts that provide a solution to the existing problem (Hevner 2004). The major problem in this research is the lack of a correct BIM adoption methodology within the architectural curriculum (Barison & Santos, 2010; Mandhar & Mandhar, 2013; Poerschke et al., 2010).

The knowledge that was missing was a developed strategy to transition from exciting methods to a method of architectural education in Lebanon which explains, accommodates, and facilitates BIM and its new requirements and opportunities.

- This research will contribute to knowledge through the guidance of how to implement BIM within the whole curriculum in Lebanon from the first year to the fifth year using standalone and integration approaches together.
- The second contribution focuses on how to expand BIM knowledge and understanding through providing a dense literature review, where the reader can understand the systems and its capabilities within architectural education.
- The fourth contribution to knowledge is in the level of details of the implementation process within different courses in the curriculum. And this is by describing how BIM can be integrated throughout different modules within the architectural program in Lebanon.
- The final contribution to knowledge is the outcome of the research which sets a guideline for how to implement BIM through basic strategies that can be applied in Lebanon and any country that follows the 5-year architectural education program explained in chapter 6.

1.8. Research Limitations

The time frame of this research is three years during which the focus on BIM is on specific topics, yet several limitations are present:

The research has a limitation regarding its approach. The actual changing of the curriculum or the real-life experimentation of a new curriculum in the university is hard and restricted. Also, the approach of this research is the design science research system, then the output is mainly artifacts represented as frameworks built and validated through negotiations and interviews with professionals. This limitation is due to the short period of study, the whole period of study was 3 years and the framework is developed at the end of the second year. That makes the real-life validation difficult to be applied.

In addition, this research was limited by the interviews cases. Reaching interviewees online is not as effective as on-site invitations. Also, being in Lebanon restricted the interviewees even more were within this zone. And with the presence of COVID-19 pandemic situation, even reaching the local interviewees became more challenging.

1.9. Thesis Structure

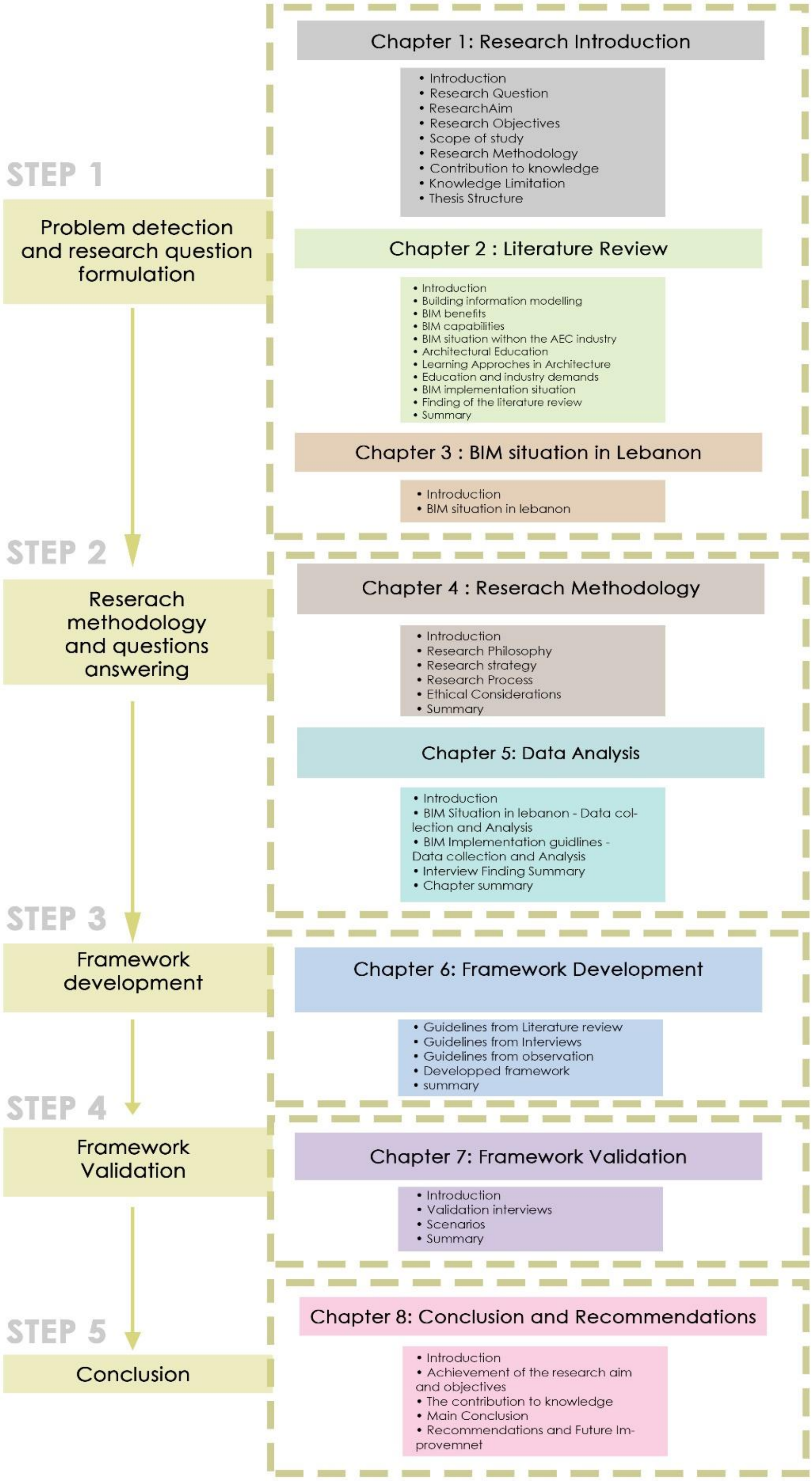


Figure 1-3 Research Structure

The research structure is based on the elaboration of seven chapters, as represented in figure 1-5 above. The process of the workflow is briefed below in the form of steps:

Step 1: Problem Detection and Research Question Formulation

The base of this research is initiated within the first two chapters that are concerned with the introduction and the literature review. In chapter 1, the motivation, aim, and objectives are outlined. The research questions are formulated, and the hypothesis is defined. Upon identifying all the previous, the scope of the research is assigned and the methodology of the research is developed. The next phase is the literature review that is elaborated in chapter 2. The chapter discusses the existing status of BIM in the AEC industry as well as the architectural educational field, whilst comparing conventional methods with the industry's demands. A brief description about BIM definition, adoption benefits, and barriers is presented. The chapter provides a deep understanding of BIM implementation and how it has been taught within the architectural programs, along with the present gaps.

Step 2: Research Methodology and Answering Questions

The second step of the research involves chapters 3 and 4. In chapter 3, the research methodology is developed where the research philosophy is chosen, the research strategy is explained and the research design is planned. Moreover, the chapter explains the data collection method used and the ethical issues that are taken into consideration. Moving to chapter 4, the focus is on problem identification through a set of case studies. Different case studies are presented and analyzed, and semi-structured interviews are assessed. The findings of both are analyzed as quantitative and qualitative results that highlight the major problems and gaps.

Step 3: Framework Development

Based on the findings of the previous chapters, the development of the framework takes place based on the output of the literature review in chapter

2 and those of the quantitative and qualitative data in chapter 5. The results of the previous three shall help in developing a new curriculum to implement and for its results to be tested valid.

Step 4: Framework Evaluation

The evaluation of the framework in chapter 7, expects the future of BIM in the new era and discusses the implementation of the BIM framework within the architectural educational sector and the professional field as well as through a series of interviews and interpretations. The framework also involves the validation process through testifying implementation of real scenarios.

Step 5: Conclusion

Chapter 8 presents how the thesis has covered the aim and the achieved objectives of the research. It arrives at the final conclusion of the research and provides recommendations and opinions for future researchers.

Chapter 2 LITERATURE REVIEW: BIM WITHIN THE EDUCATION

This chapter provides the material related to previous studies and researches that focused on Building Information Modelling (BIM), starting with its emergence as a needed demand and exploring its benefits of implementation and capabilities as a multifunctional tool. Next, the current situation of BIM in the Architecture, Engineering, and Construction industry (AEC) is examined in different parts of the world and majorly focused on the successful case of the United Kingdom and the scope of Lebanon. Moreover, this chapter looks into the focus on the shift to the implementation of BIM in education, which involves the learning approaches and theories adopted, and how the introduction of BIM meets the architectural curriculum objectives. In addition, the latest strategies for BIM implementation in different parts of the world are surveyed as well. The chapter closes with identifying the barriers to BIM implementation within academia and summarizes the findings of the literature review.

2.1. Introduction

"In a fast changing, challenging and technologically driven industry, it's more important than ever to build your knowledge and skills to get the job done better and faster."

(Valance et al., 2018)

It was predicted in 2016 by Herman et al., that the upcoming era was to witness a transition in the industrial sector through the introduction of new technologies in communication. A similar concept considered that every time period is dominant with a certain tool. Hence after the dominance of the CAD tool, BIM was expected to be its replacement as a new innovation (Autodesk University, 2017). HM Government Report (2015) states that the UK government's vision back then adopted BIM implementation as a strategy for development and enhancement in the construction sector.

Architects tend to showcase their ideas in the tools that allow them to translate their designs flexibly and with the high visual quality (Johnson & Vermillion, 2016). Therefore, the tools they choose to devise frequently represent the technological progress achieved by humans in this field. The new architectural tools innovations improve the user's capability in finishing their design work with minimum errors and gaps between the designs, construction, and manufacturing processes. The adequate implementation of BIM shall ensure its full capacity use as a tool; therefore it is important to understand its aspects and capabilities. The first step in teaching BIM to students is to introduce them to the concepts and theories of the BIM system, and how BIM tools are used. Tutors must focus on integrating BIM within the given courses to deliver results that align with BIM outcomes.

The process of BIM is a collaborative one where it involves the participation of people from different backgrounds and disciplines; their behavior, process, and exchange of information during the project's life cycle. BIM, as a technological tool, acts as a catalyst for the collaboration process. The successful implementation of BIM requires full collaboration between the client and the project team during the whole processes of the project.

The current role of BIM technology for the Architects, Engineers, Constructors, Owners, and Operators (AECOO) is fundamental since it gives the engineer the privilege to visualize the design and construction of the project up to the operation (Eastman et al., 2011). The models generated by BIM represent a great illustration of the facility throughout the project phases. The final outcome is a building information model that includes all the data, objects, and parametric representations. In addition, it also includes where analysis can be performed and information can be extracted when necessary for a better delivery and decision-making processes (AGC, 2005).

The rate of BIM implementation has witnessed significant growth in different parts of the world (NBS, 2018, McGraw-Hill Construction, 2012; Jung and Lee, 2015). The drive to adopt BIM was due to the successful delivery aspects which BIM achieved in preventing low productivity, poor functionality, rework, and waste at the different project and organizational levels (Deutsch, 2011; Smith & Tardif, 2009).

The application of BIM in the field of architectural education implies two areas of focus. The first one focuses on modeling and representation, where it is important for students to understand the authoring and production capabilities of BIM. The second one focuses on the management and collaborative work that BIM achieves, which is associated with BIM level 2 maturity (Kocaturk et al., 2013). The digital process, which BIM involves, eases the process of information storage and exchange and therefore achieves a paperless process in the production of the building (Deutsch, 2015).

2.2. Building Information Modelling

2.2.1. BIM Definitions

The definition of BIM was set by individuals and institutions. Different researchers have provided a definition for the BIM system, each serving the definer's aim (Almutiri, 2016).

A lot of debate took place over the necessity to have a consistent definition for BIM. Main supporters for this idea were Goucher and Thurairajah (2013), Brewer et al. (2012) and Building Smart (2012), who urged for the need of having a consistent BIM definition that describes BIM including its technologies, processes, and systems. Supporters believed that this measure should reduce the misconceptions and misinterpretations within the BIM context. This research aims in seeking clarity in information, hence the following section reviews BIM definitions.

The definitions linked to BIM and technology emerged from researchers who focused on the technological aspect of BIM. Fischer et al. (2004) considered BIM as information technology since it enables a technological approach in achieving design integrity, virtual representation, and prototyping. It also performs simulations and access, retrieve, and maintain all the data related to the building. Another view was introduced by Weygant (2011), where he argued that the early days of BIM focused on its ability to represent objects instead of shapes including lines, arcs, curves, etc. which evolved later to distinguish BIM with its ability to perform analysis on the model, detect clashes in design, select products, and conceptualize the whole project.

A similar view was reinforced by Azhar et al. earlier in 2008, where he approached BIM from its technological aspect by being the outcome of adopting parametric modeling techniques that are object-oriented. When CAD revolutionized the industry back then, it was the outcome of the first release of parametric feature-based modeling, where this parametric model consists of the creation of geometries that can be controlled using parameters.

And these parameters can be connected to other geometry dimensions or logic expressions (Camba et al., 2016). The impact was reflected in the way organizations developed their 3D models and the process of design change. With BIM technology, objects are associated with physical, functional, and project life cycle information. The change implied on an object automatically maintains the relationship between the adjacent objects (Azhar et al., 2008).

A later approach for Azhar et al. in 2012 adopted the technological aspect of BIM, where it considered it as a project simulation that combines 3D models with interconnected information throughout the whole life cycle of the project (Azhar et al., 2012). The successive views of Azhar et al. (2012) categorized a model as BIM with the requirement to include object attributes and support changes that are reflected automatically in the different views of the model.

Another perspective was that of Krygiel et al. (2008), who argued that BIM is a complete set of design information that connects all the information related to the building, which is stored in an integrated database. Thus, the model information is considered parametric, being interconnected where one change to the model is directly reflected on the whole project (Krygiel et al., 2008).

For a lot of researchers, BIM was seen as a result of a change in the process, which was emphasized within its definition. Eastman et al. (2011) adopted the definition of BIM resulting from a technological change and argued it was a process change. The change in the process was linked as a reflected outcome from the technological aspect of BIM. For instance, technology allows the development of enhanced visualizations in a project which are represented by intelligent objects that contain information. BIM technology involves changes in the key processes required to develop a whole building model together, which, in turn, implies a fundamental change in the process of work involving contracts as well. The support of an Integrated Project Delivery (IPD) acted as a catalyst for the stakeholders in the construction industry to deviate from the traditional approach of working independently and adopt a collaborative way of working (Eastman et al., 2011).

BIM Defined Technology and processes allow people to work with information efficiently and effectively throughout the whole life cycle of the project and between all stakeholders. Hardin (2009) sustained this view with his perception of BIM being not only a model but a changing workflow pattern and a process of project delivery that facilitates collaboration and implies a change in the approach of the working team.

In the context of BIM and process, researchers found it difficult to isolate both sides. They reinforced the idea that BIM represents a transformation in the construction industry, where it offers a set of new technologies, processes, and policies reflected in the roles, relationships, and deliverables of the construction industry. The figure below illustrates the observations of Succar (2009), who suggested that BIM is the convergence of policy, process, and technology which motivates concurrent and innovative changes within the project teams of the industry and the market.

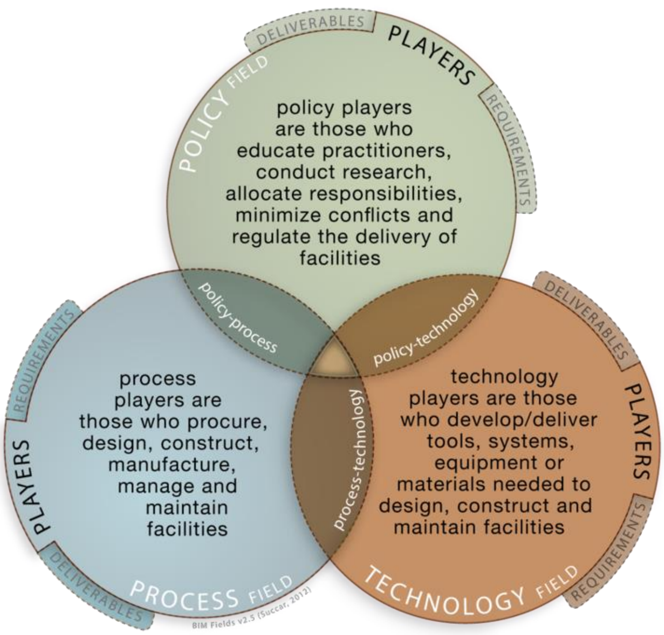


Figure 2-1 the BIM framework includes three interlocking Fields (Succar, 2009)

Figure 2-1 conveys the relationship between BIM process field, policies field, and technology field. The BIM process field reflects a plan that details the inputs and outputs and positions the events in relation to their occurrence from the outset to completion. The contributors within the process field are all the stakeholders involved in the project, including clients, the design team, and contractors.

The second field involves the players in policies who offer guidelines and support the process of decision making, which results in reduced risks and minimized conflicts. BIM works effectively to improve decision making in building design by providing the AECOO with the essential data and analysis performed through third parties' software, such as daylight and energy use analysis or structural studies. (Bank et al., 2010).

The final field comprises the players in the technology field who develop the designated software and hardware to be implemented in the construction industry. Pentilla (2006) sees that the formation of these 3 fields of activity result in their union in the creation of a methodology that supports the management of the building design and project information across the whole life cycle.

The third category of BIM definition focused on its intensive informative aspects and the quality of the information provided. Throughout history, the process of management and communication information was through the use of paper-based systems and verbal instructions. The feature of BIM which allows the digital representation of information takes the industry to an advanced level (Azhra et al., 2012).

Sebastian et al. (2010) emphasized the definition of BIM as a shared digital representation model that includes shared information among different project stakeholders. The information BIM definition facilitates collaboration and supports the act of decision making. Later in 2010, Sebastian stressed how BIM information model reflects the roles of the project stakeholders during its different stages and allows them to extract, update, and exchange information. In a recent study by Dave Philp in 2013, BIM was defined in terms of collaboration, communication, and high quality of information all linked and reflected in the deliverables and improved outcomes of the business. This interpretation was moreover emphasized in the BIM definition provided by the UK Government in 2013. It considered the essential value of BIM is achieved with the collaboration that takes place throughout the whole life cycle of the project and through the shared creation, organization, and exchange of intelligent and structured information within the 3D model (BIM Task Group, 2013).

> *"Building Information Modeling technology supports architects throughout the design process. Gain more insights earlier in the process to meet your clients' requirements and deliver projects with improved quality and efficiency."*
>
> Autodesk, 2020

The official website of Autodesk mentions that BIM supports architects in making fruitful decisions at the early stage of the design process. Moreover, BIM is well known for its uses as a visualization, coordination, collaboration, and analysis tool to aid architects (Autodesk, 2020).

Different publications have included a variety of BIM definitions, where each publication suggested its own interpretation of BIM causing confusion to readers (Barlish et al., 2012). Different perspectives of disciplines have resulted in the absence of a consensus on a harmonious definition or single explanation of BIM (Race, 2012). However, all the introduced definitions of BIM reflected its capability in transformation and impacted the construction industry (Kaseem et al., 2014). Miettinen et al (2014) argued that BIM should be "analyzed as a multi-dimensional, historically evolving, and complex phenomenon," which opens up several perceptions for BIM including its digital visualization for a building, a 3D object-oriented model, and deposition of project data (Miettinen et al., 2014).

Between the various definitions set by the researchers and institutions, the educational sector will not be able to support all BIM definitions epically since professionals didn't agree on a single definition.

The architectural learning objectives proposed by this research are to implement the BIM within the Lebanese curriculum and will not study the architectural software and its complications; rather they will implement the whole system with their preliminary tools knowledge. What students need in their architectural education varies between modeling, capturing, visualizing, performing analysis, and data gathering from a shared model. However, creating a detailed structured model, where future architects understand the various uses and protocols of BIM, is an essential part of the BIM system. When it comes to the advanced level of BIM as a management or collaboration tool, the concept for students at the undergraduate level tends to be more theoretical and does not cover the system in its advanced capabilities.

2.2.2. BIM Standards

In order to ensure that the construction projects delivery is safe with minimal errors and optimized quality, a number of guidelines, regulations, codes, and standards were formulated to regulate the construction process (Winch, 2010).

These principles reflect a combination of understanding and knowledge, which meet the requirements of any construction project and the expectations of stakeholders (PMI, 2008). The presence of guidelines and standards, which specify materials, calculation methods, quality levels, and practice methods organizes the construction industry in all parts of the world and ensures the wellbeing of societies (Timmermans et al., 2010). The concept of standardization involves bringing together the society around written standards within the competitiveness of different conventions (Timmermans et al., 2010). Howard & Björk (2008) highlight that the communication process between different specialists over a long period of time can be critical to maintain.

The study of Maradza et el. (2013) involved BIM standardization processes in the UK and the US. Although the development process was rapid, the observations of the study concluded that minimal participation for end-users, excessive self-interest, and incompatible processes were recorded. In the UK, the BIM Task Group developed the UK BIM Strategy 2011 required the implementation of BIM level 2 in all publicly procured projects by the year 2016 (BIS, 2011). This strategy was supported by standards, such as the BS1192 standards (BSI, 2013 & 2014) and the CIC's BIM Protocols (CIC, 2013). In the US, the applied BIM standards were those developed by the National BIM Standards (NBISM) (NIBS, 2007) and the American Institute of Architects (AIA) (AIA, 2008, 2013a & 2013b).

The growth of the population and the economy is reflected on the need to increase infrastructure and housing to adopt the rising numbers. This implies growth in the global construction industry with a maximum forecasted rate of 85% by the year 2030 and the need for more efficient ways of working, such as the 3D model approach delivered by BIM, which is gaining a big insight (Van, 2015).

BIM allows professionals in the construction industry to plan, design, visualize, and manage to build projects with ultimate optimization and efficiency. These features have gained BIM its popularity in the market and urged the formation of an international framework that sets the working schemes of the industry altogether in different parts of the world (Naden, 2019).

a) National Standardization

The table below summarizes the BIM standardization and policy initiatives by many countries worldwide (McGraw Hill, 2012; McGraw Hill, 2014)

Country	Organization	Standardization and/or Policy Initiative
USA	U.S. General Administration (GSA)	• National 3D-4D BIM Program in 2003 • BIM required in all final concept approval for all major projects since 2007 • 3D, 4D, and BIM technology deployment encouraged in all GSA projects • GSA BIM Guide Series
	National Institute for Building Science (NIBS)	• National Building Information Modelling Standard (NBIMS) on Building Energy Performance(BEP)
UK	UK government	• Model-based BIM (level 2) mandated on all public sector projects by 2016. • Commitment to BIM in Government projects over a 5-year time frame
	BIM Task Group	• Support and assistance in transitioning to BIM and electronic delivery • Information sharing environment (Operations Building Exchange COBie)
	AEC (UK) committee	• Unified standard for the Architectural, Engineering and Construction industry CAD & BIM in the UK
	British Standards	• Information sharing standards created (PAS 1192:2)
Finland	Senate Properties	• Models meeting IFC standards in its projects mandated since 1 October 2007 • BIM Guide called Common BIM Requirement 2012, COBIM
Norway	Civil State Client Statbygg	• BIM mandated for the lifecycle of their buildings. • All Statbygg project using IFC/IFD based BIM by 2010 • Statsbygg Building Information Modelling Manual released in 2007
	Norwegian Homebuilders Association	• Norwegian Homebuilders Association BIM Manual
Singapore	Building and Construction Authority (BCA)	• BIM e-submission system mandated for regulatory submissions in 2015 • Singapore BIM Guide
Hong Kong	Hong Kong Housing Authority	• Full implementation of BIM on all its housing development projects by 2014 • BIM standards, user guide, library component design guide, and references.
South Korea	Korean Ministry of Land Infrastructure and Transportation	• BIM mandated for all projects over S$50 million and for all public sector projects by 2016
Australia	(MLIT) BEIIC (the Built Environment Industry Innovation Council)	• National Building Information Modelling Working Party reporting to BEIIC • NATSPEC National BIM Guide developed in 2011

Table 2-1 BIM policy in the USA and adoption in North America (McGraw Hill, 2012; McGraw Hill, 2014)

b) International Standardization

With the emergence and booming of BIM in the global construction market, the need for an international standard, which organizes the process of BIM implementation associated with its benefits on the industry, was vital (Naden, 2019).

The Industry Foundation Classes (IFC) released a program for standardization in 1997, this program is considered the most ambitious. It has been developing since its release and is generating successful projects. Many individuals and institutions have been working on developing themselves by practicing standardization with a great focus on BIM standards (Azhar, 2011).

According to Jons Sjogren, Chair of the ISO technical subcommittee, the ISO 19650 standard will support the widespread use of BIM and therefore will promote the efficiency of projects. Sjogren stated that the British Standard BS 1192, which was previously tested and applied, and the available specification related to PAS 1192-2 have already proved their capability to reduce construction costs by 22%. These were moreover the basis of the development of ISO 19650 (Naden, 2019). Sjogren believed that the ISO 19650 will promote better collaboration between designers and contractors in projects, and will achieve better efficiency in information management on an international level (Naden, 2019).

The first two parts of ISO 19650 were dedicated to deal with organizing the digital information related to buildings and construction, including BIM and information management (Naden, 2019). The third part includes future standards that are oriented towards managing the operation of assets. BIM is furthermore included in part five, which is dedicated to the digital built environment, security-minded BIM, and smart asset management (Naden, 2019).

2.2.3. BIM Maturity

The level of maturity of BIM can be determined based on behavior and competence (Anderson et al., 2003). BIM maturity is the combination of action, attitude, and knowledge. Thus, once the organization understands BIM and develops adequate knowledge, the attitude showcased by planning for implementation can commence through the assessment of BIM capability, which is translated as an action (Anderson et al., 2003). The support for this approach was met with the development of tools that measure BIM capability in terms of maturity levels (Wu et al., 2017).

BIM has been adopted on different levels in various countries. Table 2-2 reflects the relative BIM maturity index levels in multiple countries (Mustaffa et al., 2017).

Country	BIM Maturity Index Level	
United States of America (USA)	**BIM Level 3**	• The AIA has been a driving force in promoting the Integrated Project Delivery (IPD) model which contractually bringing the client to collaborate at early stage in the delivery of a project. • The collaborative approach of the IPD model allows for increased data sharing between the design and project teams. • The AIA has produced a suite of documents which are based on the IPD model.
United Kingdom (UK)	**BIM Level 2**	• Mandated by the UK government in 2016 • By 2016, level 2 BIM will be mandatory on all public sector projects, including delivery of all project and asset information, documentation and data • In 2016, The UK Government has called for the wider industry to adopt BIM Level2 • It is generally understood that current Joint Contracts Tribunal (JCT) contracts (as well the NEC contracts) are well equipped to address the requirements of Level 0 BIM and Level 1 BIM • For Level 2 BIM, the only document to be inserted is called BIM protocol as a supplement document into the main standard form contracts. • The UK Chartered Institute of Building (CIOB) in 2012 had launched its Time and Cost Management Contract 1st Edition 2013 which incorporates Level 2 BIM by way of a protocol • In future, UK has the vision for Digital Built Britain / UK BIM Level 3. The Digital Built Britain strategy takes the next step in integrating these digital technologies, transforming the approaches to infrastructure development and construction and consolidating the UK's position as a world leader in these sectors. It will based on fully computerised construction.
Finland	**BIM Level 2**	• Foresight the identification of needs and opportunities and the value for users, owners, and builders and development of new concepts; • Currently, no published standard form construction contracts that specifically address BIM in Finland; at present, General Services Administration (GSA) in the USA and the Association of Finnish Contractors (AFC) collaborate in establishing BIM standards • In 2012, Finland through its Building SMART collaborated with other international organizations from a few countries has developed open BIM Standards and processes to support the use of BIM implementation; • As founded at present, there are no published BIM friendly contracts in the Scandinavian region (Finland, Denmark, Norway).

		There is very little material in the countries on how BIM is contractually integrated.
Australia	**BIM Level 2**	• In spite of the growing number of Australian based projects adopting BIM, thus far, Level 0 BIM to Level 2 BIM seem to be most extensively used form of BIM in the Australian construction market; • At present, there are currently no published standard form construction contracts that specifically address BIM in the Australian construction market ; the only provisions and requirements in implementing BIM are likely by adopting bespoke contract.
Singapore	**BIM Level 1**	• The Building and Construction Authority (BCA) in Singapore led a multi-agency effort in 2007/2008 to implement the world's first BIM electronic submission (e-submission). through the CORONET's e-PlanCheck Automated Code Checking; • Currently Singapore does no published standard form construction contracts that specifically address in BIM. The only provisions and requirements in implementing BIM by private sectors are likely by adopting bespoke contract.
Hong Kong	**BIM Level 2**	• Even though Hong Kong is an active BIM practitioner in construction; currently no published standard forms of contracts that specifically address BIM in Hong Kong construction projects.

Table 2-2 BIM maturity index levels in multiple countries (Mustaffa et al., 2017)

The leading country in BIM adoption was the USA, where it has attained BIM level 3 maturity index and incorporated BIM use contractually through involving the client in the project from the early phases and promoting the share of information between project teams (Mustaffa et al., 2017). Generally, BIM level 2 maturity index was widely reached in several countries in Europe and Asian continents, such as UK, Finland, Hong Kong, and Australia. Although some of these countries have addressed BIM requirements in their contracts, such as the JCT and CIOB in the UK, most countries currently have not published standard forms of contract that address BIM specifically in their construction projects (Edirisinghe et al., 2015) or are still at the early phases of BIM adoption reflected in level 1 maturity index such as Singapore. For instance, in Malaysia, BIM application is bounded to the extensive use of BIM level 2 with no material on how BIM is addressed contractually (Enegbuma et al 2015). The adoption of BIM in contracts is mostly represented by initiatives taken by the private sector and by adopting bespoke contracts such as the case in Australia (Mustaffa et al., 2017) .According to Chew and Riley (2013), most BIM adopter countries are taking the approach to only reference and adhere to BIM protocol document in their agreement between different parties of the project.

One of the most commonly used tools for measuring BIM maturity was the BIM wedge diagram developed by Bews and Richards in 2008, which signifies the 3 key stages of BIM following Level 0 (Succar, 2015).

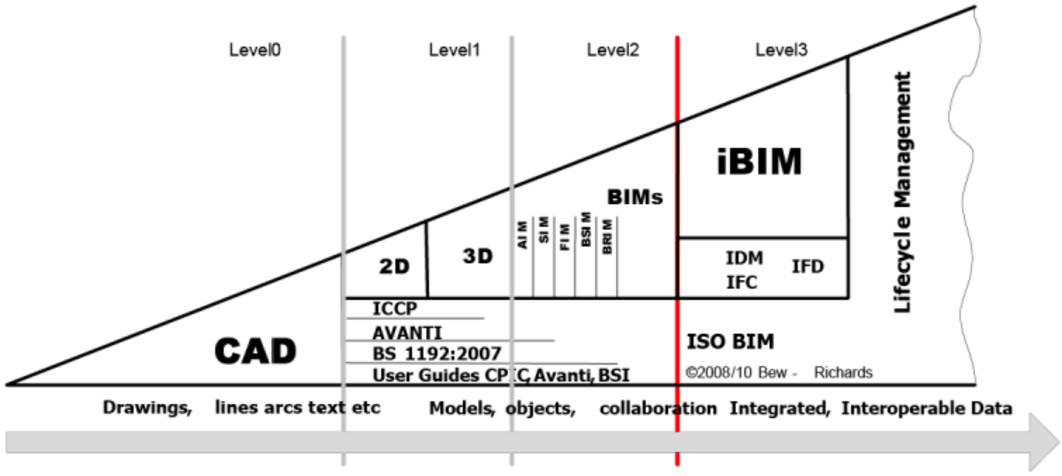


Figure 2-2 BIM implementation levels in industry by Bew & Richards (2008) (Source: BIM Thinkspacer 2015)

The NBS National BIM Report in 2017 explained the different levels of BIM, this, in turn, became the criteria to assess the compliance of an organization to the assigned levels of BIM. In the UK, the government recognized that the transformation process in the construction industry towards full collaborative work within BIM is a progressive one with clear identifiable milestones, set between levels ranging from 0 to 3 as explained below (NBS, 2017):

Level 0 BIM

Level 0 is considered the pre-level of BIM where no collaboration of BIM occurs. Level 0 comprises 2D CAD drafting for simple forms of information production represented on paper and/or electronic prints (RIBA Plan of Work 2013 stage4).

Level 1 BIM

Level 1 is represented with a gradual shift from 2D CAD towards 3D CAD and BIM which includes the production of information. In 2017, The Scottish Futures Trust stated a list of points to be achieved in order to attain Level 1 BIM. These points include defined roles and responsibilities, adoption of naming conventions and arrangements, create and maintain specific codes, and spatial coordination for the project. An adequate hierarchy for information sharing and document management should be agreed upon (NBS, 2017).

Level 2 BIM

The Scottish Futures Trust distinguishes Level 2 BIM by collaborative working and by the process of exchanging information that is specific to the project, which is shared between the different stakeholders. If any project party supports CAD software, it must be able to export to one of the common file formats that are compatible with BIM, such as Industry Foundation Class (IFC) or Construction Operations Building Information Exchange (COBIE). Level 2 BIM was the working method approached by the UK government, where it was set as a minimum requirement for public projects (NBS, 2017).

Level 3 BIM

The most defined vision for Level 3 BIM is outlined in the level 3 strategic plan of the UK government, where they have defined the requirement of specific key measures (NBS, 2017):

- Establishing new "Open Data" standards that enable easy data sharing across the international market.
- Updating the contractual framework for projects dealing with BIM in order to avoid confusion, ensure consistency, motivate collaborative working, and open data sharing.
- Creating a cultural environment that achieves cooperation, learning, and sharing.
- Training the clients of the public sector to implement BIM methods that are concerned with data requirements, contractual framework, and operational approaches.
- Motivating the national and international growth and creating new opportunities in the technology and construction industry.

2.2.4. BIM Dimensions

For each level of BIM maturity, a respective BIM dimension is adopted to reinforce the collaboration and data sharing process as well as to support the process of decision making. Researchers have stated that BIM has a multidimensional capacity denoted by "nD", where "n" represents the unlimited number of dimensions that could be added to BIM (Aouad et al., 2006, Eastman et al., 2011; Kamardeen, 2010)

The proper use of BIM technology has the capability to change the way project participants communicate and collaborate with each other and therefore influence the whole construction process (Lu & Korman, 2011).

The BIM model may include specific assigned parameters to the existing information contained in the model for the purpose of project complexity and stage requirements. These pre-defined parameters are known as "use-cases", which can be defined as BIM dimensions. These assigned dimensions enhance the data within the model and promote better understanding. The common BIM dimensions are 3D, 4D, 5D, 6D, & 7D where each has its own purpose use within the project timeline. BIM dimensions and uses are explained as follows (United BIM, 2019):

- 3D: represents the 3 geographical dimensions (x, y, z) of a building's geometry. It has visual capabilities that allow stakeholders to visualize the building at the early conceptual phase. 3D BIM enables effective collaboration and modeling with a great focus on structural issues.
- 4D: is associated with planning and scheduling for the project's construction. 4D BIM is used as a tool to plan on-site activities and clarify the sequence and time required to complete installation and operation. It provides enhanced information related to the timeline expectations and reflects any possible delays upon the changes that occur on the planned construction activities.
- 5D: is concerned with the cost analysis and budget related to the project. 5D BIM helps in estimating the costs associated with the work

scope, including material, required labor, and equipment. It moreover highlights the changes implied in cost upon the update or change in material, equipment, or systems. Its use allows the extraction of the costs associated with different scenarios.

- 6D: is focused on the sustainable aspect of the project, where it enables the analysis and prediction of the energy consumption for a building model. With 6D BIM technology, the industry takes a one-step approach beyond the traditional approach by focusing on the upfront costs of the project, which helps in formulating a clear idea on how money spent on the design shall achieve sustainability and reduce future operational costs.
- 7D: is linked to the operation and maintenance phase of a building facility. 7D BIM is an exceptional approach where every information related to the management of a building is stored within the building information model. The 7D BIM allows to keep track of the important asset data related to the installed equipment: warranties, manuals, status, technical specifications, etc. It ensures that everything stays in the required shape and performance.

2.3. BIM Benefits

The outlining of the benefits of BIM was built upon individual efforts of researchers surveying the advantages that BIM has achieved and the successful experiences attained by companies, who were the leaders in adopting BIM. One of the leading examples was the UK case, where the NBS report states:

> "*Since 2016, the year of the mandate, a further 20% of the industry has adopted BIM in the UK*".

(NBS, 2018)

The national report of BIM states that more than half of the industry has adopted BIM (56%) by the year 2016 to reach (74%) by the end of 2018 (NBS, 2018). The survey recorded advantages identified by the respondents regarding BIM adoption in construction. These advantages are highlighted below:

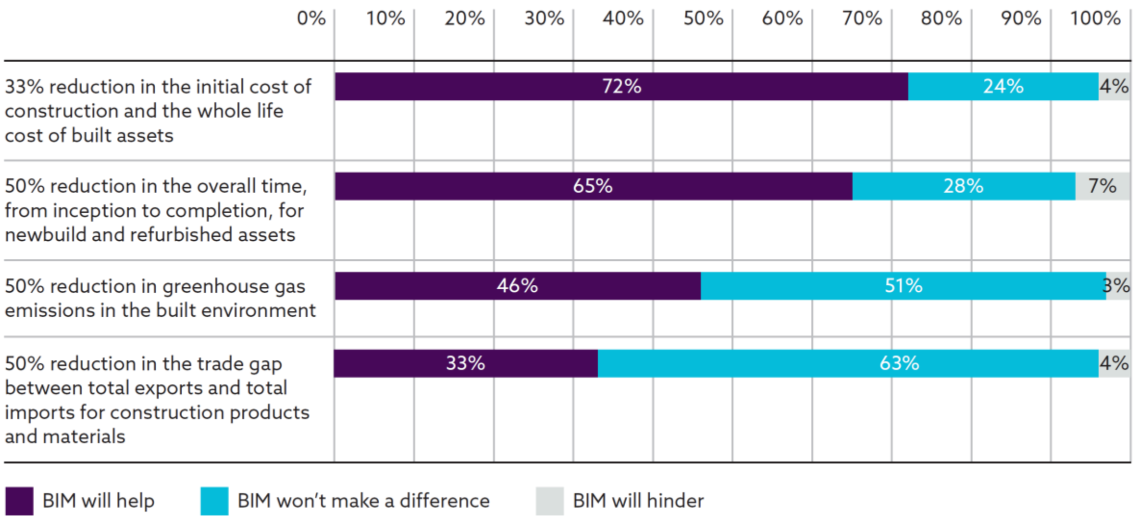


Figure 2-3 Benefits of BIM (NBS Report 2018)

• 72% of the respondents believe that BIM adoption will decrease the initial and total life costs of the construction by a percentage of 33%.

• 65% of the respondents consider that BIM will decrease the whole project's time for new and existing refurbished projects by 50%.

• 46% of the respondents see that BIM will reduce the emission of greenhouse gases within the construction industry by half.

• Around 33% of the respondents believe that BIM will lessen the trade gap between imports and exports for construction materials.

Mott MacDonald stands as one of the top leading construction companies in the UK, which was the forerunner in adopting BIM. The company has identified BIM benefits as follows:

- BIM achieves better outcomes in collaboration by using one model which connects all project members of different disciplines (client, consultant, contractor, supplier…). This shall enhance the project delivery and quality.

- BIM enhances the performance to be superior. When BIM is used, different design options and facilities can be compared and the decision will be based on a more efficient, cost-effective, and sustainable solution.
- BIM allows for improved solutions through providing generative modeling technologies that, in turn, yield cost-effective solutions.
- BIM attains better certainty through its model which visualizes the project from early stages and helps the owners in operating and generating awareness in the design content. This allows them to perform changes to achieve the desired results before the beginning of the construction stage.
- BIM allows fast delivery for the project. The ease of visualization allows time saving in the planning phase by almost 50%. Design problems are detected at the early stages of the planning by performing different simulations for various disciplines.
- BIM reduces the risks related to health and safety. The use of the BIM model, asset, and operation managers has the opportunity to enhance public safety and optimize the operations on site. Also, BIM offers the chance for contractors to use all complex details from the model before heading to the site.
- BIM offers more precision. When all project members work on one model, everyone will be capable of detecting any issue and resolve it prior to performing the construction stage, which eliminates the cost and time impacts of redesign.
- BIM generates less waste since it offers exact quantities with less material waste. The precise scheduling of the program, materials, and equipment enables the ordering of the exact quantity and accurate delivery. This creates more space for materials on site with minimal damage.

- BIM is a process of constant improvement, where all members of the BIM project can place their feedback concerning the information and the performance of the members and process.
- BIM improves the whole life asset management since the executing projects using BIM contain component information, which help in the processes of order, operation, and maintenance.

2.4. BIM Capabilities

BIM, in the definition of architectural education, is greatly linked to the benefits it offers; in particular, the enhancement of a student's performance year by year. As soon as the 3D model is created, the process of BIM commences (Saks et al., 2018). One of the most distinguished advantages of BIM is its capability in detecting design errors at the early phases of the project design. All the information related to the building elements is transformed as data is implemented in the software. BIM eases up quantity take-off, cost estimation, and building energy analysis that are all extracted from the assigned project's parameters.

The different aspects of BIM are not concerned with architectural features only, but they are extended to cover all disciplines of the building such as structural, mechanical and electrical models. The integration between these systems is used to detect any possible errors at the pre-construction level and therefore mitigate risks, financial losses, and time-wasting. The final product of the BIM process is an accurate representational model of the whole building which resembles the one to be executed (Azhar, 2008).

The main feature of architecture is normally concerned with the process of designing buildings. The futuristic view of the design process and its output focuses on the workflow of the drawings and the model. Besides, it is important to ensure that the implementation of BIM supports the objectives and values of the architectural process. For architects, the main value has generally been concerned with whether the design is represented in the conceptual model, optimum function, innovative method, or an integration of all three elements. Other engineers may have different objectives and areas of focus. For this purpose, different tools of analysis, stimulation, and information need to be present to serve the choices of all specialized engineers.

2.4.1. BIM as an Information Capturing Tool

Collecting data is the first form of the BIM process, where a deep understanding of the context and the project's requirements is critical for architecture students (Gledson et al 2017). The next step relies on how students are going to make use of BIM as a digital design tool. Initial models are basically simple digital forms that aid in visualization; hence students need to understand the process of simplification in the first place and the context of the model development in the second place. It is worth noting that in this phase site analysis is important to collect as much information as possible that acts as data input for BIM (Coates, 2013).

For several years, technological shifts have been taking place, such as laser surveying methods. For instance, a tripod-mounted laser scanner has the ability to measure the distance of an element's spatial point per second, resulting in what is known as a point cloud used in developing a 3D model. With such time-saving technology, the need to measure single points is excluded. Such technology has promised the industry in turnkey "scan to BIM" functionality (Photo Modeler, 2017).

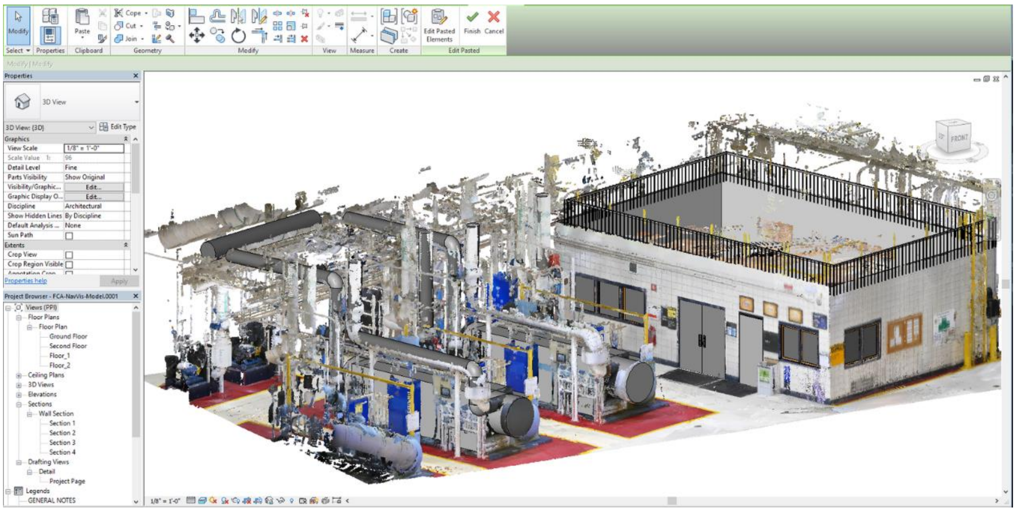


Figure 2-4 Photogrammetry (Source: https://www.navvis.com/blog/53-scan-to-bim)

Another powerful tool is photogrammetry, which captures information and measurements directly from a photograph. It enables the construction team to capture photos for all sides of a building and then upload the pictures to generate a 3D model using BIM. Although this tool cannot provide millimeter details as the ones provided using the laser survey, it is still considered an affordable and accessible option (Tuttas et al., 2017).

2.4.2. BIM as an Authoring Tool

Form and space represent the most critical meaning of architecture (Ching, 1997). Creating BIM spaces and objects is normally the job of the architect. Tools such as Formit and Sketchup can be used for object massing at conceptual phases. When using BIM, the designer is creating both the geometric components and the information related to the form all at once. In further stages, the level of object detail may certainly increase. The level of BIM detail (LOD) defines how the model can represent and achieve different levels of detail refinement ranging from detail options 100 to 500. The level of detail increases as the project phase proceeds from the concept phase to the as-built phase (BIM Forum, 2019). The attached properties to the model objects are used for structural and environmental analysis.

The ultimate goal in architecture is to create a space that meets the purposes of function, aesthetics, and buildability (Allen et al., 2016). The ability to create the desired geometry acts as a main constraint. Some complex geometries may require external modelling tools before getting the model into the authoring tool. Also, the question of visual authenticity is present: when shall the model be rendered to appear well?

Figure 2-5 BIM authoring tools (Source: https://parametricmonkey.com/2016/06/20/bim-ecosystem/)

Students should learn to differentiate between developing their ideas through representing objects to think with and objects to look at for the purpose of presentation (Yakeley, 2000).

2.4.3. BIM as an Analysis Tool

"Data and analytics are already shaking up multiple industries, and the effects will only become more pronounced as adoption reaches critical mass."

(McKinsey Global Institute, 2016)

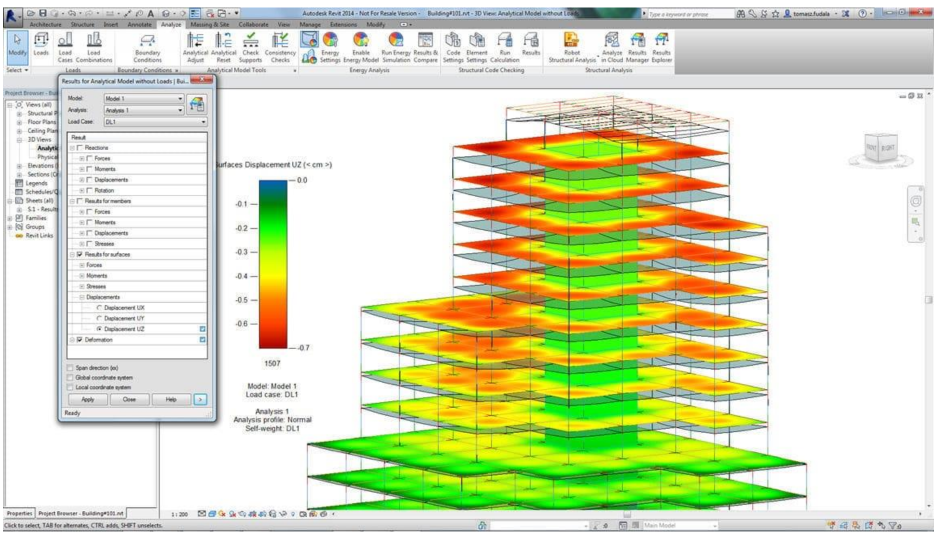


Figure 2-6 environmental analysis using BIM software
(http://www.archiexpo.com/prod/autodesk/product-1773-305950.html)

An architect's main job is the ability to achieve an effective design, which meets the building performance criteria (Bazafkan, 2019). BIM adoption implies that a building model is derived from the process of the building. The model, which is developed by default, could be used for building analysis. Linking graphical objects and assigning the respective data can be used for different forms of analysis that answer several concerns such as structural analysis, energy analysis, GIS integration, and scheduling of equipment ordering. One particular importance is building energy simulation models related to environmental concerns. The subject of building energy simulation is taught as a standalone course or as an integrated one (Hoppe et al., 2017). With more information provided, the designer is able to better understand and communicate decisions (Maver, 2000).

2.4.4. BIM as a Tool to Develop More Sustainable Solutions

The last century has witnessed a high demand for sustainable buildings that offer eco-friendly solutions (Wong & Jan, 2003). The main sustainable considerations are the indoor air quality, acoustics,, light, and spatial integrity (Wong & Jan, 2003). Determinants of building integrity are represented with building automation, structural stability of the building, fire safety and security, earthquake resistance, maintainability, and resources efficiency, such as materials and energy (Fadeyi, 2017).

The introduction of BIM has updated the design and documentation processes of the building, simplified the management of construction, and provided the owner with better facilities in the management and operation of the building (Dadi et al., 2016). Formerly, the primary benefits of BIM were measured by economic performance. For instance, improved efficiency of building design, construction, and maintenance will eventually result in better delivery for the project value at a lower cost (Zanni et al., 2013).

The addition of buildings to the existing built landscape necessitates sustainable thinking in order to meet the expected future challenges in the aspects of energy consumption, material resources availability, and land use (Rafsanjani et al., 2018). The concepts of BIM and sustainability have developed from different market factors, yet they share a common core.

Moreover, the carbon emissions of a building project act as one of the main key performance indicators on how the building is performing environmentally. Design changes in BIM are not only linked to costs, but to carbon emissions as well. The selection of material and specification has a direct impact on carbon emissions. Thus, savings associated with carbon emissions are indicated within a BIM model. Companies, which prioritize the goal of reducing carbon emissions from their building project, are capable to analyze different alternatives and materials through BIM from early stages of the project and identify the design solution that offers them the optimum reduction in carbon emissions (Spencer & Daniel, 2015). Incorporating BIM in sustainability is of great effectiveness and advantage. When performing energy analysis to determine the building's efficiency, the model can be imported into other programs, such as IESVE and EQUEST. However, the choice of software depends on the type of the analysis (Zanni et al., 2013).

2.4.5. BIM as an Output and Communication Tool

The quick pace of the development of the construction industry goes simultaneously with the need to use the most recent technical solutions (Niu et al., 2019). Stakeholders in the construction market have shown a growing interest in keeping up with new BIM technology and are therefore requesting a BIM tool as a requirement for their product delivery (Travaglini et al., 2014). This necessity turns more complex and challenging when dealing with high-end and large-scale projects, where a large number of design team members and subcontractors are integrated. Hence, collaboration between all team members becomes vital. Besides the technical and statutory compliance, the outputs generated by the BIM model help in evaluating the design quality (Sacks et al., 2018).

BIM acts as a communication tool for architects (Mustaka et al., 2019). Outputs generated from model analysis help in evaluating the quality of design and technical and statutory compliance. BIM has been greatly associated with the concept of virtual pre-construction, since it represents a digital twin of the actual building that allows accurate visualizing of the building in one model (Gozali at al., 2019). This grants the architect the opportunity to carefully consider the user experience and the operation of the building. With the use of technology, a shift from traditional manual drawing representation to digital design and execution processes is taking place (Heidari et al., 2018).

2.4.6. BIM as a Visualization Tool

The basis of virtual reality is represented through the use of BIM, being considered as a cutting-edge tool for design visualization (Corke, 2017). The process of design is under continuous change. Softwares such as Revit, Navisworks, Rhino BIM, Dynamo, and Grasshopper allow the consultant and the client to visualize the design from the initial to the final phases including rendered perspectives.

The majority of architectural modelling tools have hidden line views, which do not allow the visualization of the interior space behind. BIM in architecture has eliminated this issue and enabled the viewer to see the underlying interior space, including finishes (Sacks et al., 2018). This feature encourages interior designers as well to adopt BIM in developing their interior and exterior spaces (Yakeley, 2000).

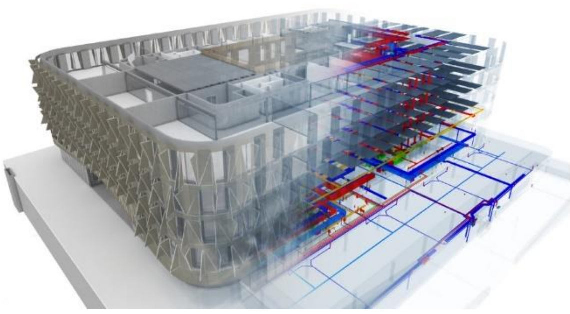


Figure 2-7 BIM Visualization (source: https://architizer.com/blog/practice/tools/vectorworks-architect-2017/)

Any change in the design is automatically updated in the model, drawings as well as the schedule. This stands as one of the most important features of BIM and puts the generated product of BIM as a well-coordinated, updated, and reliable one (Sacks et al., 2018).

2.4.7. BIM as a Manufacturing Tool

As BIM has implied changes in the design, it has changed the manufacturing process (Vass et al., 2017). The more the evolution of adoption of BIM continues to grow, the more the importance of delivering smart BIM-based objects can certainly boost efficiency by adding more objects to the library of the BIM tools (Bahrami et al., 2019). Manufacturers are increasingly asked for BIM data to incorporate into BIM models and object properties. It is vital in the construction sector to have a seamless relationship between the supplier, the contractor, the consultant, and the owner (Stamatiu et al., 2019). With BIM being a requirement in the construction industry, the availability of BIM-ready models by the manufacturer for any building element (steel, glazing, furniture, fixtures...) can ease the collaboration process for potential future clients. Therefore, providing BIM-ready models and data can increase the chance of the product being specified by the consultant and potentially choose the supplier of a BIM-focused product (Talbot, 2019).

The shift towards BIM focuses on design, manufacturing, and assembly, where BIM offers students the opportunity to model and then create an actual demonstration using machines. Here, the model acts as an instruction for the cutting machine that shall manufacture the final product (Love et al., 2014).

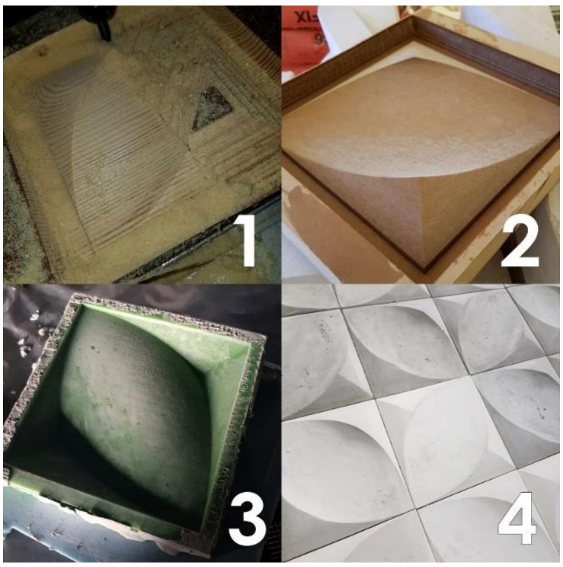


Figure 2-8 BIM to Manufacture using CNC machine (Researcher source)

In the construction industry, rapid prototyping tools have been used but are restricted to concept modelling in architecture (Kalay et al., 2014). Contour crafting has the potential to produce full-scale models from digital data. A lot of buildings have been constructed using large-scale manufacturing methods. CAD is used in both construction and manufacturing, yet its use is limited to the design-drawings work. Several architects are engaging in the digital models as a production of the building components (Paoletti et al., 2017). The ability to use 3D CAD models with analysis generated by computers creates impressive architectural forms. Moreover, the generation of large-scale molds using CNC machines is considered a reliable and feasible option for architects (Kolarevic, 2005).

2.4.8. BIM in Professional Practice

The practices of BIM resemble professional practice features. According to Miller (2016), practices whether small or large, have a great opportunity when it comes to adopting BIM. With BIM being a requirement in almost every tender, the necessity of working with BIM cannot be ignored if one seeks progress and challenge in a business. The collaborative approach of BIM provides the practice with embedded quality control. The process of BIM encompasses the asset data, which necessitates moving in a process of approval, authorization, and verification from ISO 19650-1(Scheffer et al., 2018).

2.4.9. BIM for Project Lifecycle

The product delivered using a BIM tool promotes the increase of the building's value, lessens the overall project's duration, produces market-ready facilities, offers accurate quantity take-off and cost estimates, and optimizes the operation and maintenance process of the facility (Papadonikolaki et al., 2014). The term "Project Lifecycle Management" was explored by Sarno (2012) and linked to BIM. With the implementation of BIM in the construction project management and infrastructure lifecycle management, the project's stakeholders are capable of gaining new competences throughout the whole project. For clients, BIM offers more control at the design and execution levels (Papadonikolaki et al., 2014) and enables the achievement of better-cost savings (Tahir et al., 2018).

2.4.10. BIM Management

For project managers, BIM offers an effective project management tool (Jadhav et al., 2017). The technical aspects of a BIM tool, such as clash detection, modeling, and material takeoff cost estimation can be useful in the planning and management of a project. Therefore, it is important for project managers' seekers to have a clear understanding of how to use a BIM tool and invest it in their career in project management (Fasano, 2018).

2.4.11. BIM Collaborative Tool

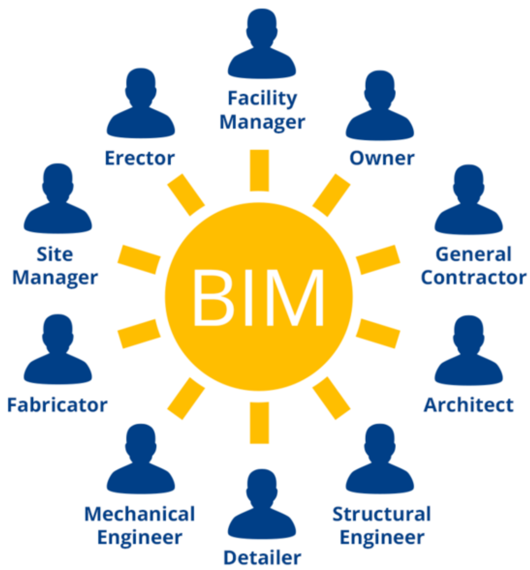


Figure 2-9 BIM collaboration between the different disciplines
(Source: https://www.tekla.com/about/collaboration)

BIM stands as a collaborative tool in the construction industry since it involves different disciplines in one environment (Ojaiko et al., 2016). The essence of BIM implementation falls in the collaborative workflow process. Project participants need to collaborate together in order to enhance the efficiency of the delivered product (Succar, 2009). This process enables the effective communication between different project team members, especially when it comes to identifying problems, and enables them to share their knowledge and data on one single platform. Sufficient information implies effective communication, which allows stakeholders to exchange updated and accurate information to better perform the process of reliable decision making (Sacks et al., 2018).

Succar (2009) defines three stages of BIM: object-based modelling, model-based collaboration, and network-based integration. Any BIM project is based on a specific activity sequence. The process involves high levels of data, information, and knowledge transfer. The successful delivery of a BIM project relies greatly on the effective collaboration between project owners and design teams.

The main challenges faced in construction are cooperation, coordination, and integration. BIM use presents one great solution to cope with these challenges. However, when it comes to project management, few studies do exist about BIM in this area (Sacks et al., 2018). Many studies have recommended the construction industry adopt the Integrated Project Delivery (IPD), yet few have identified it as an ultimate objective for construction project delivery (Eastman et al., 2011).

When comparing construction processes, BIM has proved to enhance collaboration and information sharing where it is linked with high levels of efficiency on both terms (Bryde et al., 2013; Grilo and Jardim-Goncalves, 2010; Lee, 2008). Sebastian (2011) endorses that multi-disciplinary collaboration can be attained with the optimal use of BIM, but when changing key parties' roles, setting new contractual relationships, and overcoming re-engineered processes bring new challenges.

Moreover, Bryde, Broquetas, and Volm (2013) recognize that coordination defects stand out as the second largest negative impact to project performance after software issues in 35 construction BIM-enabled projects. The issue of collaboration cannot be addressed by a single contract or economic theory (Liu et al., 2017). Few studies have explored the complexity of collaboration when implementing BIM. It turns out that all project participants have to be aligned with self-interest, company's requirements, and project objective. Hence, collaborative process is one of the key factors for BIM success and its full potential can solely be achieved when knowledge and technology are considered.

2.5. BIM Situation within the AEC industry

Building Information Modeling (BIM) is an expansive knowledge domain within the Design, Construction, and Operation industry and a great deal within the Architectural and Construction Engineering industry (Gerges et al., 2017).

BIM stands as an improvement in process and as a tool, which involves a set of virtual aspects, concepts, and systems of a building in one environment (Azhar, et al., 2010). BIM involves applying and maintaining a collaborative digital representation of different disciplines throughout different phases of a project (Eastman, et al., 2011). Sacks et al. (2008) explained BIM as the utilization of a database infrastructure to summarize built facilities having viewpoints of stakeholders, where they can query, simulate, and estimate activities and monitor the building process as a lifecycle entity.

Various BIM applications are present which can be used to support constructability, analysis, scheduling, cost estimating, and sequencing (Memon et al., 2014). BIM has a great capability in integrating within the project's lifecycle, which is a key tool for project management (Nagalingam, 2013. Chen, 2011).

Research showed that BIM use can take place in different tendering routes in order to enhance the over-all process (Bolpagi, 2013. Ciribini, et al., 2015). Many governments, such as the UK (HM Government, 2012), USA (Wong, et al., 2009) and Australia (BuildingSMART, 2012) have set strategies for implementing BIM within the construction projects.

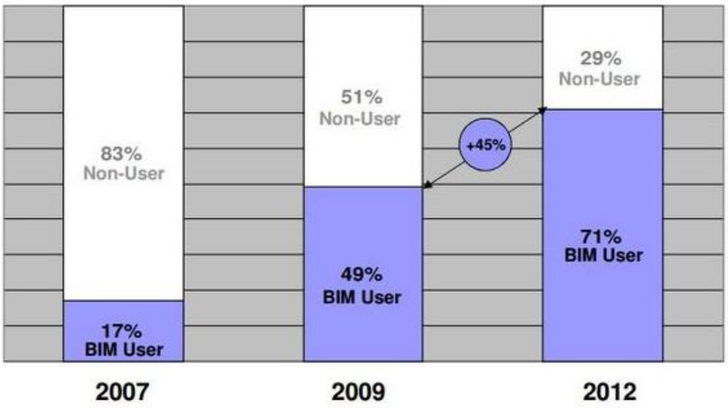


Figure 2-10 BIM adoption in North America in 2007 , 2009 and 2012
(Source :https://geospatial.blogs.com/geospatial/2013/06/bim-adoption-reached-71-in-2012.html)

For example, in North America, BIM adoption by contractors has increased greatly from 2007 to 2012 (McGraw Hill, 2014). In the UK, the government mandated BIM use in its governmental projects, which have a minimum of 5m capital cost by 2016 in order to decrease project time, delays, and costs overruns (Constructing Excellence, 2008). This decision caused pressure to the contractors, where they had to make a rapid transition into BIM in order to meet the specified project demands (Withers, 2012). Consequently, with the close economic relationship between the UK and the Middle East, the obligation of BIM adoption has resulted in its wide spread in the Middle East (Gerges, 2016). Moreover, there are many multi-national companies who have offices based across the Middle East region, which implies a wider BIM adoption in construction processes across the Middle East. Furthermore, this is motivated due to the rapid growth of mega and complex projects in the UAE, Qatar, Bahrain, Kuwait, and Saudi Arabia (Gerges, 2016).

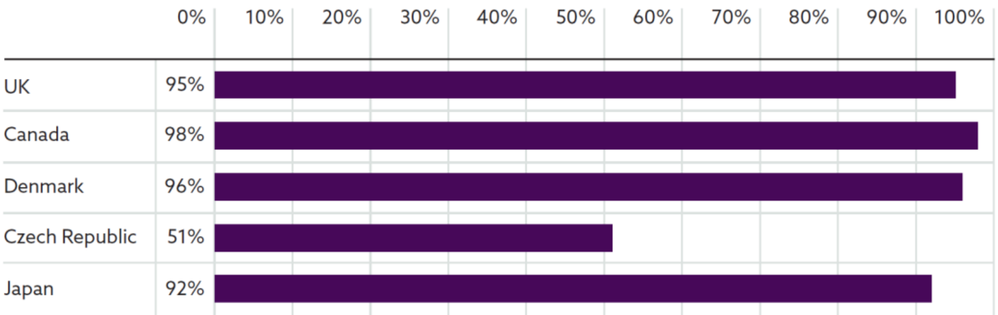


Figure 2-11 Awareness (Source: NBS international report 2016)

According to the NBS report (2016) and as shown in the figure above, more than 90% of various countries have awareness of BIM, except for one. Czech Republic, being the lowest, has recorded 51% BIM awareness between the UK, Canada, Denmark, and Japan. Canada recorded the highest rate with 98%, followed by 96% for Denmark, 95% for the UK and 92% for Japan (NBS, 2016). These rates imply that BIM is well known across a range of countries and is in an increased demand in the market, where BIM adoption has become a requirement for many projects and within different countries. As for the case of Denmark, it is expected for the percentage to witness an increase following the same track of other countries that have adopted BIM.

The same report surveys the awareness and current use of BIM by participants. Parallel to the previous results in the figure above, the countries have recorded similar results in BIM use versus BIM awareness. The leading countries were Canada and Denmark, where the percentage of awareness and use by the respondents was marked at 67% and 78% respectively. As for the UK, it recorded 48% and Japan 46%. Finally, Czech Republic, with the lowest percentage of awareness, was marked for being used by 25% (NBS, 2016).

When comparing both previous figures, one can conclude that although the percentage of BIM awareness might be high, the actual personnel's awareness and use might turn out to be lower than the reflected rate. For instance, although the UK has recorded a high BIM awareness rate of 95%, the percentage of respondent's awareness and use did not exceed half with a percentage of 50%. This suggests that although professionals are aware of the advantages of BIM use, some barriers and challenges still hinder broad implementation in the professional industry.

The construction industry in the Middle East is witnessing rapid growth due to the increase in population as well as the implied growing demand in infrastructure projects. Middle East region consists of the Gulf Cooperation Council (GCC), North Africa, and some countries from Asia. BIM stands as a procedural and technological shift in the Architectural, Engineering, and

Construction (AEC) industry (Succar, 2009). This was furthermore supported by Eastman through the devise of computers instead of drawings in the design of buildings (Eastman, 1975). The evolution in computer science and information technology have altered big time the work processes of most industries (Chan, 2014).

2.5.1. Barriers for BIM Implementation

The implementation of BIM in the construction industry has been limited by several barriers which were mainly concerned with: the lack of a national standard, the high cost of application, the lack of skilled personnel, and organizational and legal issues. Each mentioned barrier can be divided into two or three sub-categories as represented in table 1, and is supported with a detailed literature reference (Liu et al., 2015).

Category	Item	Literature
Lack of national standard	Incomplete national standard Lack of information sharing in BIM	Bernstein & Pittman, 2004; Thomson & Miner, 2006; Björk & Laakso, 2010; Azhar, 2011; Aibinu & Venkatesh, 2014; Alreshidi et al., 2014
High cost of application	High initial cost of software High cost of implementation process	Allen Consulting Group, 2010; Thomson & Miner, 2010; Azhar, 2011; Ganah & John, 2014
Lack of skilled personnel	Lack of professionals High cost of training and education	Smith & Tardif, 2009; Allen Consulting Group, 2010; Sharag-Eldin & Nawari, 2010; Becerik-Gerber et al., 2011; NATSPEC, 2013 ; Wu & Issa, 2014
Organizational issues	Process problems Learning curve Lack of senior support	Arayici et al., 2011; Won et al., 2013; Aibinu & Venkatesh, 2014; Demian & Walters, 2014
Legal issues	Ownership Responsibility for inaccuracies Licensing problems	Thomson & Miner, 2006; Chynoweth et al., 2007; Azhar, 2011; Udom, 2012

Table 2-3 Summary of barriers in the implementation of BIM (Source: Liu et al., 2015)

Researchers have pinpointed the importance of the presence of a national strategy development for the implementation of BIM, where it would set out the priorities clearly and provide guidance for the construction industry (Azhar, 2011; Thomson et al., 2006). Moreover, well-developed practical strategies that take into account the different types of industry work are important (Bernstein et al., 2004). Although some building guidelines were developed, yet, there is no general standard that organized the construction. A clear consensus regarding the implementation and use of BIM is not present yet (Bernstein et al., 2004).

Al Reshidi et al. (2014) have highlighted BIM issues related to data inconsistency and the willingness to share information between all project's stakeholders. Aibinu et al. (2014) have furthermore emphasized that BIM necessitates the inclusion of the capability to transmit the data and to reuse the embedded information in the graphical mode. More barriers related to the costs associated with BIM implementation were highlighted by Ganah et al. (2014). These costs were mainly due to the requirement for BIM education and training, administrative and startup costs, and transitional and behavioral costs. The cost of purchasing BIM software and updating the IT facility pushes investors to study the adoption option thoroughly (Allen Consulting Group, 2010). Therefore, BIM adoption was supported by large-scale companies rather than small ones, since they have the resources and financial capabilities (Ganah et al., 2014).

The AEC industry is marketing BIM adoption in various ways. The essence of implementing BIM is training, and education (Sharag-Eldinet & Nawari, 2010). The presence of suitable personnel in the company is important whether the company chooses to train existing resources or hire new ones. Also, the integration of BIM within the organization results in behavioral and organizational changes in order to fully adapt BIM (Allen Consulting Group, 2010). Studies demonstrate that the implementation of BIM at the undergraduate level can greatly enhance the competitive level of students in the job market (Wu & Issa, 2014). BIM education at the post-secondary level is expected to meet the requirements of the industry. The lack of adequate training of BIM professionals presents a barrier to proper BIM implementation and use in the AEC industry (Becerik-Gerber et al., 2011).

The implementation of BIM faces organizational issues which are concerned with the professional liability, process problems, and trust (Won et al., 2013). BIM collaborative work highlights the problem of interoperability (Demian & Walters, 2014). Some managers are resistive to the introduction of new technologies and are concerned with the effect of the learning curve of BIM. Also, they encounter challenges from inadequate knowledge in the process of adopting BIM, all of which present barriers for BIM adoption (Aibinu & Venkatesh, 2014).

BIM legal aspects are important to consider. The top legal risk of BIM is concerned with BIM data ownership. The main concern is that if owners pay for the architectural design, there is a great possibility that they claim the ownership of the design documents. When stakeholders, other than the clients and architects, contribute in BIM integration licensing problems may arise (Azhar, 2011). Another concern is how to determine the person of authority to access data and the party concerned with the inaccuracies which might form a great risk (Thomson & Miner, 2006). The main concern for the project's stakeholders when using BIM is the security of confidential data present in the BIM model, where a range of legal and security issues have been identified in several construction projects (Chynoweth et al., 2007; Udom, 2012).

For instance, in the case of the UK, the survey included in the NBS report (2019) highlighted the main barriers that still hinder the implementation of BIM. The major barriers were clients ignoring the requirement for BIM use, the lack of BIM training, consequently, the lack of in-house expertise, the associated costs for BIM implementation, and the time required to speed and catch up with the new technology. More barriers of less majority were the small scale of projects that resulted in using traditional schemes rather than BIM technology within, the absence of an established framework and standard tools which set the working protocol with BIM, and the lack of collaboration between the project parties due to the differences in the level of BIM expertise. Minor contributing barriers can be classified as the requirement of a specific software to operate the BIM system; concerns related to liability; the presence of professionals who don't see the benefits of BIM use, and professional being unsure of the UK's government commitment to BIM (NBS, 2019).

A study by Siebelink et al. carried in 2020 interviewed BIM specialists of different positions in an attempt to define the current barriers for implementing BIM in the industry. The results showed that several factors contribute to the low level of BIM adoption. First, the study reveals that the core structure barrier was related to people's motivation, their competence, and their capacity to learn and implement BIM. This problem was found across professionals from all organizational levels (Siebelink et al., 2020). Second, the limited support from the managerial level was often related to low BIM maturity levels. It was considered that the support of the management can motivate the organization and the employees to shift towards the use of BIM, especially during the early stages of BIM implementation. For companies who recorded a high level of BIM maturity, the barriers were outside the organization and were concerned with poor definition and use of standards and the lack of appropriate BIM software for construction activities (Siebelink et al., 2020). However, these companies with high levels of BIM maturity were capable to overcome the barrier of full BIM implementation through working with the supply chain, in order to ensure the optimum achievement of BIM benefits (Siebelink et al., 2020).

2.5.2. Moving Towards Full BIM Implementation

"If people's intentions become professional practice, the next five years will see a very rapid transformation in how information about buildings is created, shared, and used. "

(NBS, 2016)

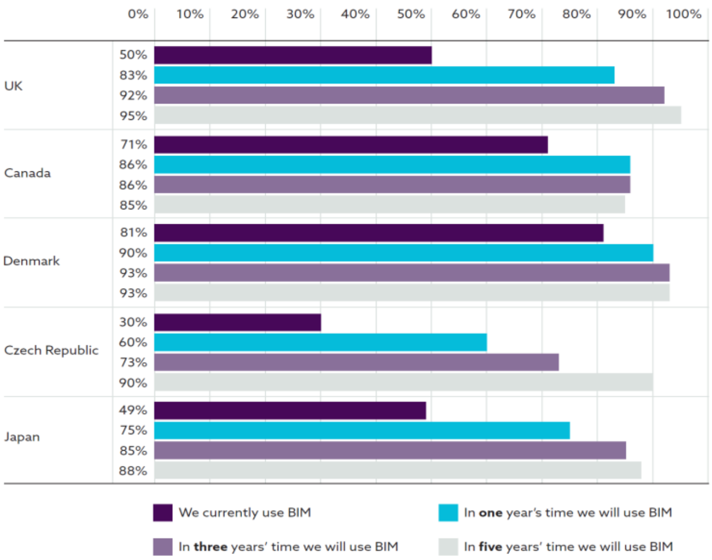


Figure 2-12 Future of BIM (Source: NBS, 2016)

The above figure compares the countries that were earlier analyzed for their BIM awareness and adoption regarding willingness for BIM use in the future. 4 timelines are assessed for each country: the current use of BIM; the expectation to use in one, three, and five years. Although the current use of BIM between the countries vary from 30% for Czech Republic to 81% for Denmark, all 3 future timelines are expected to witness growth in the future (NBS, 2016). The intention of professionals to adopt BIM in the next five years is expected to be rapid to exceeding an 80% for all countries.

The fastest rate of increase is marked to be within the coming year of 2016, followed by a slight increase in the third and fifth years for the UK, Canada, Denmark, and Japan. Although Czech Republic recorded the least rates in awareness and use in the earlier figures, the above markings illustrate an evenly distributed rates in the adoption along the upcoming 5 years-period timeframe. The rates of BIM adoption plan might vary in its intensity from one country to another, but the final objective to exceed the 80% marking after 5 years is common for all countries.

2.6. Architectural Education

2.6.1. General Overview

The concept of architectural education that the industry is dealing with today is somehow a new phenomenon, since it implies updates on its curriculum that have been long developed and engraved since years. The traditional aspect of architectural education throughout times has depended on the idea that the master transmits knowledgeable information to the pupils.

It was in the early 19th century when the French added a new sense to architectural education with the formulation of the École des Beaux Arts, and to other similar schools later to train architects (Stevens, 2001). During the period of the next century, the field of architectural education gradually took its spot in the systems of higher education. The architectural education history is seen to have developed progressively through the movement of knowledge from the workplace into the design studios of the university. The interpretation of this movement was the focus of a study performed at the Prince of Wales Institute of Architecture in an attempt to understand the history of architectural education (Crinson & Lubbock, 1994).

The architectural education system has evolved over the years with two different systems that have overlapped in places. Firstly, the French presented the concept of an organized formal architectural education system. Secondly, the Germans presented their concept of research in the architectural education field. Similarly, the United States was the lead to synthesize both systems in a university along the concept of apprenticeship or internship, which was more adopted in the UK (Weatherhead, 1941). All of this provoked the need to develop more structured architectural education standards in different countries.

Educators have a critical role in reinforcing creativity in students, where they learn how to think and work creatively on a professional and personal level. In 2008, the members of 35 advanced economies in the world formulating the

OECD concluded that the importance of individual and society's creativity is growing (Sinay, 2018). Many countries have been working on enhancing their schooling with a greater focus on the necessity of creativity in order to keep up with the emerging trends (Sina , 2018; Bratteteig et al., 2012). For instance, several countries have initiated the idea of working on transforming instruction to achieve creative learning outcomes (Sinay, 2018). For example, the European Union dedicated the year 2009 to be "The European Year of Creativity and Imagination", which asserts that the future of Europe depends greatly on the creativity and imagination of its people. Moreover, governments of China and South Korea have updated their policies to formally include their support for creativity in schools (West-Knights, 2017). Sawyer (2015) believed that traditional schooling methods were associated with a pedagogical approach that wasn't an advocate of creativity. These conventional methods are known as instructionism, where the teaching method involves giving instructions to students in the form of lectures and the assessment of students' memorization through textbook assignments and standard exams (Sawyer, 2015). Therefore, educators and policy makers encouraged shifting away from the traditional instructional approach towards a newer pedagogy which ensures creativity within its learning outcomes (Sinay, 2018; Bratteteig et al., 2012,).

The study of Sashwati (2016) highlighted that Vitruvius and Walter Gropius believed that architectural education is majorly instructed to architects through theory and practice, which formed a paradigm for contemporary architectural education. Sashwati (2016) concluded in his study that for an architectural student to be successful, they should reflect on three major capabilities gained through their education:

- Design: the ability to design buildings is the most distinguished characteristic that a successful architect possesses other than any engineer or profession.
- Knowledge: reflects a deep architectural understanding gained through the instructed information.

- Skills: reflect in his practice different forms of skills: communication, manual, and digital presentation, modelling, etc.

2.6.2. Design Studio in Architectural Education

The core base of the architectural curriculum is the design studio, which is basically extended from two well-known art movements: The Bauhaus and the Ecole des Beaux-Arts (School of Fine Arts). Originally, design was taught by design professors who were related to associations through modelling (Kostoff, 1977). This orientation in education focused on the professional master instructing their students (Kostoff, 1997). Next, the vision shifted towards providing a more structured education that gives artists more credibility through the organization of more than 60 art exhibitions to present their work. For this purpose, various art academies were formed, such as Royale de Peinture et de Sculpture, the French Academie, established in 1648 (Draper, 1977). During the period of the 17th century, an organized group education was created, yet the idea of the master being the sole source for knowledge still existed.

With the emergence of the modern movement, led by the famous German Architect Walter Gropius, students stood up against the school system (Draper, 1977) which pushed them to abandon the system of the Beaux-Arts (Littmann, 2000). The new educational principles of the modern architecture era focused on providing the training for students to be craftsmen, introducing modern technology to arts, and the use of steel as a new building material in art and architecture to better serve people's requirements (Frampton). The teaching methods of the modern architecture era have been elevated to include lecture courses and workshops that teach students the building process from day one. The Bauhaus has been flexible in adopting new educational pedagogies, from introducing hands-on interactive workshops to reinforcing the design studio model to be a place for all the students' activities (Gropius, 1937).

Throughout the progress of design history education, some characteristics remained important since its time of inception. Nevertheless, researchers such as Austerlitz, Aravot, and Ben-Ze'ev (2002) drew four characteristics that differentiate the learning environment of the modern design studio from the former one. These characteristics are: the learning component being more reflective; the design process being more personalized, which implies more creativity; the instructor's influence on the project's product, and the full expression of the student's feelings out in the open. The fact that the instructor does not have any influence on the process of the production of work for the student and ignores the importance of the student personality being reflected on their work, since classrooms are crowded with students, the traditional design studio was characterized by the mentality of the blank slate for students since creativity wasn't a major requirement.

Lueth (2003) has highlighted other characteristics that make the environment of the design studio unique, such as the following: the influence that students have on each other and on the instructor as well and the impact of the physical environment and the products created during class time and beyond on the students. Hence, the experience of the educational environment of the design studio ought to support the components of a pedagogical, virtual, and physical space that has an influence on the participants of education: the students and instructors.

Researchers such as Dutton (1984) supported the design studio for its uniqueness, where he considered the studio as being more active in engaging students intellectually and socially rather than as a traditional classroom. He moreover highlighted the importance of shifting between different thinking models in different sets of activities, that are the drawings, conversing, and model-making representing the analytic, synthetic, and evaluative thinking models. Conversely, research such as (Ledewitz, 1985) and others had a criticizing point of view for the design studio by considering it lacks clarity and reflects a complicated learning setting.

Furthermore, Salama (2005) claims that although the design process aims to function based on the elements of intuition, logical treatment, and rigorous reasoning, yet it may not be aligned with the realistic condition since instructors tend to teach the way they were taught in school. Thus, instead of students developing problem-based learning and constructivism techniques from the design studio, they end up being restricted by the instructor's teaching format.

Different studies have been conducted by researchers in order to understand the effect of the design studio learning environment. Some have viewed the design studio as a reflexive learning environment, which makes the design studio stand out in higher education as being unique (Anthony, 1991; Austerlitz, Aravot & Ben-Ze'ev. 2002; Schön, 1985). In architectural education, the idea of experiential learning is most commonly used by scholars in studying the architectural design studio (Kolb, 1984). For example, a Chinese study examined the correlation between the academic successes of students with respect to their instructed learning styles. The research categorized students into two types: the convergers and the assimilators. The first type focuses on students who are more physical science oriented and tend to be more successful in traditional learning systems, such as tests. The second type is about students who have a strong ability in creating physical models (Jia & Kvan, 2004).

More detailed studies were performed in an attempt to understand the correlation between the design process and the experiential learning process (Kvan and Yunan, 2005), the relation between the student's progress and the learning in architecture (Roberts, 2006), the understanding of architectural concepts by students (Saalman, 1990), the production of artifacts in architecture, planning, and engineering (Purcell & Gero, 1998), and the design process and cognition examined by Chan (1995) and Lui (1996).

2.6.3. Architectural Design Education in Lebanon

In 2017, a study performed by Masri analyzed the structure of the architectural curriculums across different Lebanese universities by highlighting the four categorized core courses: the architecture design studio, the structural engineering, the building technology, and the building services. The results are represented in the figure 2-20 below.

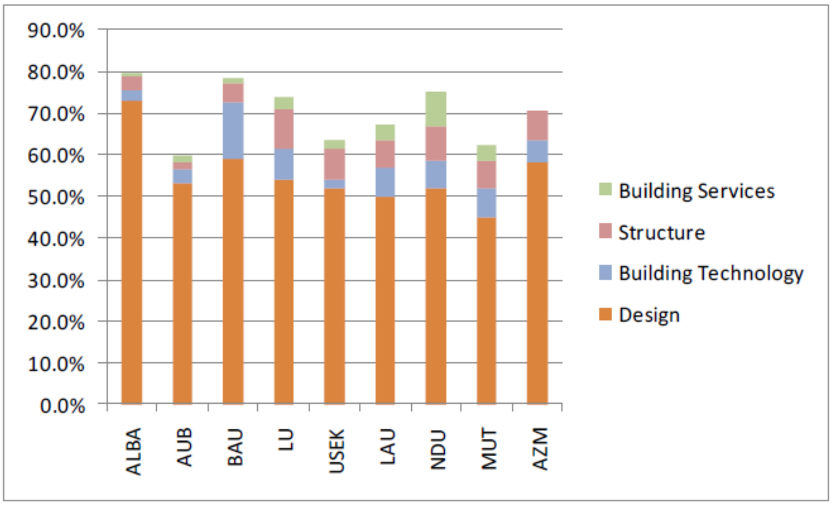


Figure 2-13 The Assessment of Structural and Technological Knowledge in the Lebanese Curriculum, Source: (Masri, 2017)

- ALBA: Académie Libanaise Des Beaux-Arts
- AUB: American University of Beirut
- BAU: Beirut Arab University
- LU: Lebanese University
- USEK: Holy Spirit University of Kaslik
- LAU: Lebanese American University
- NDU: Notre Dame University
- MIT: City University
- AZM: Al Azm Unvieristy

The highest percentage of the core course domination is the design studio, which exceeded 50% in 8 out of 9 universities where ALBA university, with its 6 year post-graduate programs, recorded 73% while that of MUT university recorded the lowest percentage of 45% with a bachelor program. Next comes the focus on building technology modules, where the percentage varied from one university to another. The highest percentage was that of BAU University with 13.5% and the lowest at USEK University with only 2.1%. Modules related to structural engineering varied between 8.2% at NDU University and 1.7% at ALBA University. The insight of universities on services system within the curriculum structure was the highest at NDU with 8.2% and lowest at ALBA with 0.8%. To sum up, the most distinguished curriculums with a major focus on the technical studies are found in the programs of the BAU, LU, and NDU Universities (Masri, 2017).

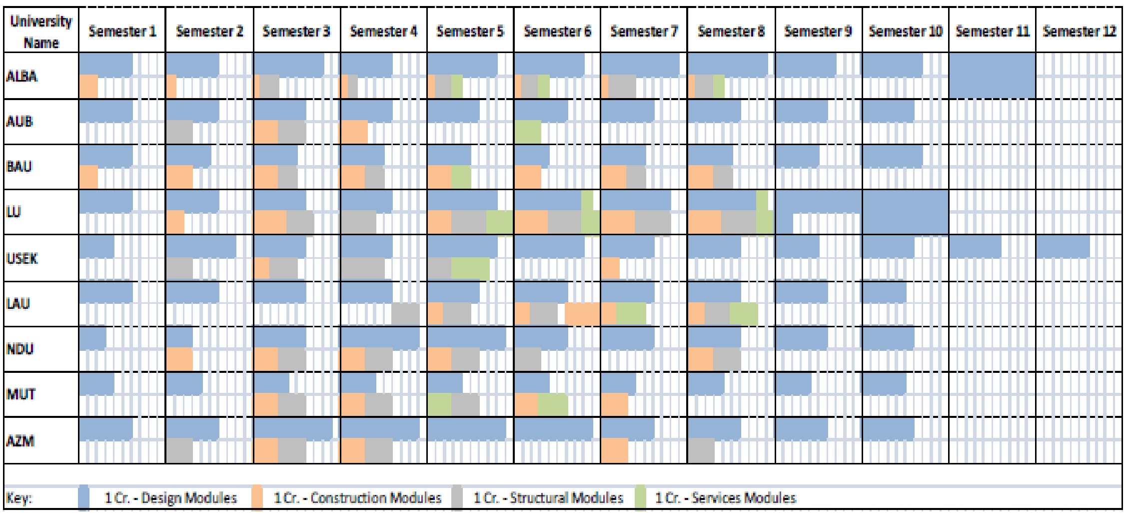


Figure 2-14 The Distribution of Core Courses over the Time Span of the Architectural Program in the Lebanese Universities, Source: (Masri, 2017)

Figure 16 shows students exposed to each category of the core courses across the time span of the architectural program. The core design module starts from the first semester in all universities up until the graduation year or post-graduation. The introduction of the technological construction modules mainly occurs during the second or third semester, with an exception for BAU and LAU Universities at the first and fifth semesters respectively (Masri, 2017). These modules include topics concerned with building materials, building systems, building elements, and details which reflect real-life practice.

Structural courses are introduced separately from the design modules either at the second or third semesters for most universities. The inconsistency of the structural courses given in parallel to the design studio, such as AUB, USEK, and MUT or the delay in introducing the structural courses such as LAU does not enable students to fully relate the building structure with the design. Moreover, when moving towards a more complex design project, a problem emerges. Students consider visualizing the building in terms of spans, loads, tensions, shear forces, and compression, which might result in designs that are not executable on site. Hence, the existing distribution of the structural engineering modules fail in terms of content and in teaching how to establish a clear relationship within the design studio module and do not motivate the student to integrate a structural solution in their design project (Masri, 2017).

The great amount of knowledge students need to acquire in the technological and the structural courses should be reflected in their architectural design process of a building. Students must be able to think about structure, systems, details, materials, and all elements of the building from the early stages of design up until the final stage. Therefore, students will acquire the skills and knowledge to draw detailed executional drawings. Therefore, a comprehensive curriculum structure shall involve the structure, construction technologies, and service systems within the functional design of a building in order to achieve efficiency and practical design solutions (Masri, 2017).

c) Accreditations in Lebanon

One of the key factors for assessing and measuring the quality of architectural academic programs is accreditation. On a competitive scale, an accredited program is deemed to be of a higher quality than a program which is not. For graduates who are willing to continue postgraduate studies or go into the market, an accredited degree should facilitate things and give them an extra advantage.

In Lebanon, there is a complete absence for a national accreditation institution for the architectural curriculum in universities. Yet, within the globalization of architectural professions is no longer limited to a certain region but rather extends through different parts of the world; therefore the advantage and the need for accreditation is rising. Several universities have prioritized quality assurance and international accreditation for their programs and have thus worked on acquiring an accreditation from international institutions, such as RIBA (Royal Institute of British Architects) and NAAB (National Architectural Accrediting Board for North America) in their process of elevating their standards and level of competition (Saridar & Elarnaouty., 2015). For instance, BAU is accredited by RIBA Part 1 & Part 2. LAU and USEK likewise acquired NAAB accreditation, and NDU has set to achieve NAAB accreditation in its 2015-2020 objectives.

The process of assessment for the RIBA accreditation involves achieving the eleven general criteria and graduate attributes set by RIBA. Similarly, NAAB has established a clear criterion in its accreditation method which establishes student performance criteria based on critical thinking, technical and presentation skills, integrated building practices and architectural solutions, professional practice, and knowledge (Saridar & Elarnaouty., 2015)

2.7. Learning Approaches in Architecture

For the past century, research in the field of high education, which focused on teaching and learning methods, has evolved with different theories that were brought forward by different schools of architecture. The learning approaches adopted for students in higher education were studied deeply in various disciplines (Marton & Säljö, 1976). The approach to student learning is directly related to their past experience in studying and understanding the concepts of the subject, which is important since it is reflected in the learning outcomes (Trigwell et al., 1999).

The process of traditional lecturing to students has been criticized and is seen as insufficient for students, since it does not develop the pre-requisites that the professional practice requires (Dochy, 2005; Forsythe, 2010). In the practical working field, young professionals should have the skills of problem thinking and solving (Grabe, 2010). The approach of problem-based learning reduces the gap between academic and practical fields (Smith, 2005). This approach forms a learning environment setting for the student, where the problem is a stimulus of real-life scenarios and a tool to identify the compulsory knowledge, which therefore drives the learning process (Smith, 2005). The approach is viewed as a classroom activity model which encourages student-centered projects rather than instructions that are teacher-centered (Yildirim et al., 2014). The problem-based method maintains that students should be active learners through constructive investigation (Dochy et al., 2005; Yousuf et al., 2010).

Different architectural schools have implemented the problem-based learning approach in their curriculums, where it has turned out to be a successful and innovative method for engineering education (Dochy et al., 2005; Srinivasan et al., 2007). The positive outcomes are seen to be as: effective problem-solving skills, self-directed and long-life learning skills, effective collaboration, and improved understanding of the course content (Smith, 2005; Klegeris & Hurren, 2011).

The common feedback from students' experiences is that problem-based learning motivates them to work harder over traditional methods. The instructor no longer has the role of transmitting information. The role is focused towards driving and monitoring group discussions.

2.7.1. Learning Theories in the Digital Ages

New technologies have implications for education and practice. A lot of changes are taking over the 21st century, which have a great impact on the learning styles that are being adopted. One of the most major changes is the reflection of new technologies on the educational level, where universities are competing with non-traditional education associations. This shall enhance teaching methods and enable universities to understand how students learn best. Aspects of current trends include distance learning, mobility, modularization, globalization, flexible learning, and work-based learning (Ashworth et al., 2004).

The new technologies that are being adopted encourage the idea of independent learning and require students to develop new skills. This implies a gradual shift from traditional teaching and learning forms into new ones, where information does no longer require the physical interaction between teachers and students, but rather focuses on the self of the student (Knowles, 1975). One example for this approach is the problem-based learning, where the learner needs to be independently responsible for his own learning.

The impact of the digital age will continue to grow while economic and social impacts on society. The tools and methods for self-learning are becoming more available to learners where they can now learn and work from home without the physical need to attend on campus. Moreover, the act of increasing modularization allows students to learn at their own pace and according to the time that best suits them (Ashworth et al., 2004).

2.7.2. Restructuring Curriculums Using the Addie Model

According to Driscoll & Carliner (2005:9), design is more than just a process and an end product. It represents a whole framework of thinking. The approaches in teaching delivered by instructors are based on a set of guidelines and strategies; known as instructional models. Effective instructional models are grounded on learning theories that best describe the methods that theorists have conducted and are believed to teach people new ideas and concepts. These learning theories often explain the relationship between information that is already known and that to be learnt.

Schneider (2014) identified two categories of design models. The first category is the Instructional Systems Design (ISD) Models, known as the Instructional Design Methods, and the second category filters more general models. These ISD models are concerned with guiding instructors to plan a curriculum, course, program, or training session. The typical example for this case is the ADDIE model, which was applied in this study during the development of the BIM implementation framework. Along with the ADDIE model, there are different other types of models which are more general or which do not align with what the research framework needs to achieve. These methods are at various levels of granularity, especially given that the term instructional design model involves various meanings. For instance, Schneider suggests that there are at least five other kinds of models other than the instructional design method:

1. Models describing a pedagogic strategy in detail (9 events of instruction (behaviorist/cognitivist), inquiry-based learning (constructivist))
2. Models relating to the quality of a design (Merrill's First principles of instruction)
3. Models that provide a method to create a design. For example, Instructional systems design models like ADDIE
4. Complementary models enhancing a design: (FEASP (emotion), Self-regulated strategy development model (strategy development), POME (self-regulation), Felder design model (learning styles))
5. Change management-related models addressing the issue of introducing new pedagogics and associated instructional design models (activity theory-based expanded learning)
6. Models describing the functions of a learning environment (The Sandberg Learning Environment Functions)

These types of models can be complementary in some ways, but not in every way depending on the nature of the project-based learning design. Hence, after the careful consideration of each model type, the systematic approach of the ADDIE model aligns perfectly with the goal of the framework development, since it targets architectural curriculum enhancement or development.

The process of research and development in education involves the improvement and validation of a new educational approach represented in the form of a learning material, tool, or learning strategy (Hartini et al., 2018). In the instructional design field in curriculums, the ADDIE model stands as one of the commonly used guides in generating an effective design (Aldoobie, 2015). The concept of the ADDIE models is structured on a sequence of systematic steps that aim at solving learning problems that result from learning resources and thus comply with the requirements and needs of students. The model steps are: analysis, design, development, implementation, and evaluation.

ADDIE model use is suitable when the focus is on a single subject matter, one learning design, and one learning media, all of which require experts in the field of specialty. The method for collecting the data relies on observation and questionnaires. The collection and evaluation of data shall be divided into four groups. The first group is concerned with evaluating data related to the form of the subject matter and its content test results. The second group focuses on evaluating the data from the test results of the expert in the learning design. The third group evaluates the test results data of the learning media experts. The final and fourth group evaluates the results of the data initiated from small group trials. The collected data is analyzed and presented in the form of descriptive quantitative and qualitative means (Widyastuti, 2019).

The stages of the ADDIE model are explained as follows:

1. **Analysis**

The first step is the activity of analysis, which includes three sub-activities. The first one is analyzing the definition of competence from the students' perspective to acquire by determining the standard and basic competencies and the learning purpose to be achieved. The second sub-activity is analyzing the knowledge, skills, and attitudes of students. The third sub-activity is analyzing the suitable materials needed for students to master the assigned competencies. The final outcome of the analysis stage is the self-evaluation and the continuous evaluation with colleagues to ensure regular analysis and improvement (Widyastuti, 2019).

2. **Design**

The second step of the activity is design and planning, which includes three sub-activities. The first one is the selection of the relevant material, which is compatible with the students' characteristics, to be achieved. The second sub-activity is setting the learning strategy to be applied. The third sub-activity is determining the assessment and evaluation tools and forms to be utilized. The design step involves the planning of the framework content and structure. The final outcome of this stage is the self-evaluation and the continuous evaluation with colleagues that guarantees the improvement of the design results (Widyastuti, 2019).

3. **Develop**

The third stage is the activity of development, which includes several sub-activities. The first one is collecting the related data sources that help in enriching the module and in creating a factual sample for the instruction design. The second sub-activity is developing the course material through acts of developing illustrations, generating schemes, creating needed graphs, editing, and preparing the final text book. The third sub-activity is running a conduction for the developed design in order to validate the draft and further develop the final revision to be implemented (Aldoobie, 2015)

4. **Implement**

The fourth step is the implementation of the developed plan through its application in the learning process and identifying its impact on the quality and effectiveness of the learning process. The process of implementation is a trial one where it is applied on a small group in order to gain input from the students and educators for the final revision (Widyastuti, 2019).

5. **Evaluate**

The fifth and final step is the evaluation that comprises formative and cumulative evaluations. The process of improvement involves a series of steps that are combined and collected as data for the formative evaluation. The final step performed at the end of the program is the summative evaluation; it aims to identify the influence on the learning outcomes for students and the quality of learning (Aldoobie, 2015).

2.7.3. The Importance of Practical Skills Development for Architectural Students

"I can think of no other profession where new graduates must wait a decade or more to be given significant responsibility because they have not acquired basic skills in university"

Yarema (RIBA, 2014)

One of the main considerations in job screening is whether the candidate has the suitable skills that meet the job requirements. In 2014, RIBA Appointments Skills Survey reported that 65% of respondents are experiencing difficulties in finding candidates with the suitable experience and the right skills. Markets are struggling to find candidates that fit some of the positions (RIBA, 2014).

RIBA have listed the top five scoring terms that require high skills and knowledge expectations, some of which are: Building Regulations and Standards, Planning System, Design and Specification; the RIBA Plan of Work, and BIM. According to the survey, more than half of employers and students consider BIM an essential skill. This reflects the effectiveness of the UK Government strategy which raised awareness regarding the importance of BIM. Yet, employers are aware that high skills in hand-drawing are still vital (RIBA, 2014).

The preparation for going through the practical field is a little bit frustrating. Graduates might lack the necessary problem-solving skills for the business issues they may encounter. Their communication skills might not be fully developed to aid them in persuading clients, contractors, planners, etc. Fresh architecture graduates might feel that clients do not fully understand or appreciate their role as architects. Therefore, in addition to the design skills and specialist knowledge that the architect acquires through their educational period, it is essential for him to gain insight on practical skills in order to prosper in a highly competitive market (Hopkirk, 2019).

The RIBA Appointments Skills Survey recorded 5% of students and employers who have a basic understanding of business management. This could be reflected in the future development of their career (RIBA, 2014). The architectural industry goes beyond the design and construction aspects towards a whole business management for the projects. It furthermore involves the deployment of resources and money. The existing gap in the graduates' skills and limited or weak management abilities, necessitate the recalibration of the architectural education in order to develop the practical skills at the level of the university prior to career engagement.

Looking at the architectural curriculum, although architectural schools encourage students to work on their own and think for themselves, theoretical knowledge is often dominant within the program. Yet, the responsibility to develop the practical skills cannot be fully put on the architectural school since the practice environment has a share in developing the practical skills further. It is vital to expose students to site experience during their study period. Integrating professional elements into the curriculum at an early stage shall have an efficient role (Utaberta et al., 2014).

A work-based activity involves practical training which is promoted as a model for future education. Normally, performance at any firm involves working under pressure and having timely deadlines, where mistakes are costly. A practicum environment at the university involves a pressure-free world without any distractions and real risks. The difference between the architectural education and the practical training environment involves forms of different functions and activities (Utaberta et al., 2014)

Education by its nature is broad, exploratory, and associated with theory. The process of learning develops forms of communication and collaboration that are essential for architectural education. On the other hand, practical training is skill-based, restrictive, and requires organized tasks and processes to achieve goals. When learning practice, the practitioner deals with situations that require problem-solving skills through facts, knowledge, and procedures from their own professional experience. The unforeseen problems force the practitioner to rethink the ways and actions in going beyond facts and theories and responding with solutions in a structured and strategic manner. The foreseen changes in the architectural education and training of architects signify a promising opportunity in creating a solid and competitive architectural profession (Utaberta et al., 2014).

2.8. Education and Industry Demands: An Emerging Technology

Up until today, computing technology has achieved great progress. The field of software design has similarly progressed greatly with new development tools, programming languages, and methodologies. The new powerful emerging technology of computing has made it easier for individual users to develop their graphical products from their personal computers (Nicol et al., 2005).

The academic field is subject to several pressures rising from new and rapid technologies and knowledge, which therefore imply high costs and create funding challenges (Ankrah & AL-Tabbaa 2015). The pressures have impacts on academic and industrial fields, which necessitates their collaboration in order to face these rising challenges successfully. The term academia-industry collaboration refers to the communication between parts of the higher education system and the industry which aims to motivate knowledge and technology exchange (Bekkers & Bodas Freitas 2008; Cho et al., 2019). The study of Leite et al. (2016) explored the academia-industry knowledge gap through surveying the top seventeen challenges of advanced technologies. Researchers emphasized how the successful collaboration of the academia-industry can support the industry in commercializing new technology and thus providing research direction to the academia (Cho et al., 2019; D'Este et al., 2011). Furthermore, the studies of other researchers explored topics related to the research agenda of the academia-industry collaboration in the construction industry (Lucko & Kaminsky 2015). The main challenges and new roles emerging from the academia-industry collaboration (Yasmin et al., 2014; Sahpira et al., 2011) and the ways in which the partnership between shapes the knowledge, attitudes and social responsibility of engineering students' knowledge and attitudes about corporate social responsibility (Singer et al., 2018). For this reason, it was seen that academia-industry collaboration has increased to become essential in the architecture, engineering, construction, and facilities management (AEC/FM) industry (D'Este & Perkmann, 2011).

Technologies encounter improvements which have been reflected in the construction industry and have gradually led to a change in this sector. The techniques of computers and their respective courses are important factors to consider in development. The construction industry has been greatly affected by new technologies involving building information modeling (BIM), prefabrication and 3D printing, wireless sensors, and automated and robotic equipment (Industry 4.0). When discussing the concepts of architectural education, it is important first to understand the basics of architecture since it differs from engineering education (Guney, 2011). The architectural process involves different aspects of politics, society, technical factors, aesthetic, economic, ecological, and ethical considerations.

Planning for architectural education requires the understanding of all of these factors and to make sure that none of these parameters are missed. This highlights the necessity for students to have an architectural background in relation to these factors (Colomina, 2012).

One of the biggest weaknesses in education is that it has not been upgraded much in the past few years. The new technological advancements are placing new demands on the construction industry. These advances include new building materials, computer software, assembly methods, and construction techniques. For architecture practices to work more effectively, they should adapt to new emerging technologies. Building information technologies act as new opportunities for the architectural profession (Andenas et al., 2012).

Lately, the increase in the implementation of BIM is changing the way many architectural practices are working. In a time where sustainable design is evolving, the need for computer software that serves the exchange of information is growing. With BIM use, an alternative approach towards the design process; procurement and construction are taken into account, especially within the changing responsibilities of the design team. For instance, all stakeholders are able to access the building information model. This requires greater teamwork, adaptation, and investment. The BIM model acts as a joint platform for all the project's team to develop their design and collaborate on one model. This ensures that all parties are involved in the design and building processes and are aware of any changes (Guney, 2011).

BIM adoption forces changes in architectural design. Questions such as how and what, are changing the way architecture is taught. Innovative thinking is a basic requirement in the introduction of BIM in education (Cheng, 2006). Similarly, communication and representation act as decisive factors in the proposal of new architecture. For architectural education to embrace new outputs in design, the process must be developed. The future of architectural concepts and practice are a crossroads between BIM and generative modelling. An architectural shift from the traditional practice to the dynamic model and digital practice is taking place (Abdirad et al., 2016).

A building model starts to take form in the design studio. The process includes the development of all engineering disciplines in one integrated design model. Therefore, the outcome represents an actual representation for the final components of the building which are derived from the design studio. BIM offers the opportunity to stat from the building product rather than ending up with it as the traditional case (Abdirad et al., 2016). This enables students to become exposed to new challenges in the comprehensive studio that replicate real-life challenges.

2.8.1. The Introduction of BIM Education

Different methods were adopted in the introduction of BIM in education (Barison & Santos, 2010a, 2010b; Gerber et al., 2011). In 2010, a survey performed by Barison & Santos, recorded that 103 schools have adopted BIM in their architectural and engineering curriculums, mostly in the United States.

A year later, Becerik-Gerber et al. highlighted in their report that the implementation of BIM in education in the United States has marked a significant progress. Between the surveyed institutions in the US, more than half have already adopted BIM with 56%. The report additionally breaks down the classes related to BIM within the architectural and engineering undergraduate programs in the US. The results reveal that the biggest contributors are the engineering courses marking 57% followed by the architecture courses with 50% and construction-related courses with 36%. The survey furthermore highlights that BIM introductions in taught courses ranged from sophomore, junior, and senior levels.

BIM introduction in architectural programs remains unique in when and how it should be involved (Gerber et al., 2011). The start of adopting BIM within the AEC courses took place during the middle of the 1990'S (Barison & Santos, 2010a, 2010b). The early 2000's witnessed several schools adopting BIM in their curriculums in the form of stand-alone courses. For instance, Madison Area Technical College in the US, introduced a third-party application on its website using Autodesk software. Students have access to three BIM computer applications as stand-alone classes. Also, California State University implemented BIM as a stand-alone course in the building construction program to help students in extracting the quantities and estimating the cost (C. M. Clevenger et al., 2010; Gier, 2008).

The University of Minnesota, which introduced BIM first by teaching Revit software to students. After witnessing its effect over four consecutive years and evaluating its strengths and weaknesses, the Dean of Architecture School expressed that the introduction of BIM in the curriculum shall produce students having high skills in BIM and high level of critical thinking (Mandhar & Mandhar, 2013).

The peak of introducing BIM within the architectural curriculum occurred in 2006, which took action using different ideas. Pennsylvania State University introduced the idea of Integrated Design Studio (IDS), which aims at teaching

BIM at a multi-disciplinary level (Barison & Santos, 2010a, 2010b). The idea involves giving students a real-life scenario requesting them to design a building given a specific program, existing site, and an allocated budget. Students are supposed to work similar to the real-life condition, where students of mechanical, electrical, structural, and architectural programs team up together to work on the project (NCARB, 2011; Penn State University, 2012).

After the top-notch period in 2006, the need for BIM collaboration skills increased within the AEC industry in the States (Almutiri, 2016). According to the report of Wu and Issa (2013), the implementation of BIM in the US was a major concern, especially with the lack of BIM understanding and collaboration between disciplines. Moreover, tutors had difficulty teaching BIM within the curriculum due to their inexperience or basic understanding of BIM.

The new era of BIM implementation suggests the shifting from stand-alone courses to multi-disciplinary (Barison & Santos, 2010a; Macdonald, 2012; Repko, 2012). The main aspects in teaching BIM rely in the questions of how BIM is taught, when BIM is introduced and in which courses it involves in the architectural program.

According to NGO (2012), BIM needs to be integrated within the curriculum and characterized with a collaborative approach. It suggests that the implementation of BIM in all engineering disciplines shall achieve better BIM understanding and aid students in experiencing BIM within the projects to better prepare them for the AEC industry.

2.9. BIM Implementation Situation within the Architectural curriculum.

There are many schools who have taught BIM based on technology or process within their systems by using different methods (Barison & Santos, 2010a, 2010b; Gerber et al., 2011; Mandhar & Mandhar, 2013).

Other scholars have suggested that BIM is about people, processes, and technology which needs to be taught through a collaborative and integrated design approach. Ngo (2012) suggests that in order to achieve a better understanding of BIM, it needs to be embedded within civil engineering programmes in the UK (Ngo, 2012). Moreover, it will help students comprehend how projects work and the needs of the AEC industry, which can help them find better jobs (Ngo, 2012).

2.9.1. History of BIM in education

BIM implementation in the AEC curriculum goes back to the mid-1990s when it started. Both, Georgia Institute of Technology and Texas A&M University, used BIM 3D modelling tools within their teaching process (Barison & Santos, 2010a, 2010b; Ibrahim, 2007). One example is the University of Minnesota, which first introduced BIM through teaching REVIT Architecture software to students in the architecture program. Dr. Cheng, Head of the Architecture School, said that the assessment of this approach after four years showed that the introduction of BIM in the first studio in the early years of the curriculum resulted in highly skilled graduates and elevated the level of critical thinking (Autodesk, 2007b).

At the start of the 20th century, several architectural schools introduced BIM as a stand-alone course within their curriculum. For instance, in the United States, Madison Area Technical College introduced in 2003 architectural third-party applications using Autodesk (Barison & Santos, 2010a; Mandhar & Mandhar, 2013). This was supported by the university by providing the students with three BIM computer applications "Intro to Revit – Revit MEP – Advance Revit" from Autodesk through the university's website MadisonCollege, n.d). Another approach took place at California State University at Chico, which adopted BIM as a standalone course in the Building Construction program, specifically through using a BIM tool to support students with quantity takeoff and cost estimation activities. (Barison & Santos, 2010b; C. M. Clevenger et al., 2010; Gier, 2008; Mandhar & Mandhar, 2013).

The concept of incorporating BIM within Architecture Programs escalated year by year. In 2006, BIM integration within architectural curriculums reached its peak; new approaches in BIM adoption took place. For instance, Pennsylvania State University introduced the concept of Integrated Design Studio (IDS) which involves BIM being used by different disciplines (Barison & Santos, 2010a, 2010b; Mandhar & Mandhar, 2013; Onur, 2009; R Sacks & Barak, 2009). This approach to BIM introduction was recognized by the National Council of Architectural Registration Boards (NCARB, 2011). The jury of the NCARB, were impressed with the idea that the university's approach provides the real-world experience to students from different engineering backgrounds: architecture, structural, mechanical, electrical, and teaching assistant. The students were given a real scenario to design a building program with existing site constraints, and allocated budget (NCARB, 2011; Penn State University, 2012). Beyond the year 2006, the AEC industry in the United States raised the requirement for more BIM collaboration skills. This concern was mainly due to the lack of BIM understanding in terms of work sharing and strategic implementation, the lack of cross-disciplinary collaboration, and the absence of a common agreement on how to teach BIM within the AEC curriculum in the United States (Wu & Issa. 2013).

Nevertheless, the important shift that took place was the move from standalone BIM courses to the multi-disciplinary approach, which was the mark of a new era for BIM in education. Later, research divided the BIM approach into three categories inter-disciplinary, multi-disciplinary, and trans-disciplinary. These categories focused mainly on when and how BIM should be taught, what are the teaching possibilities, what is the level of education and its relationship to BIM teaching, what are BIM topics related to the architectural field ,and the ones that could be good targets to teach (Barison & Santos, 2010a; Macdonald, 2012; Repko, 2012).

2.9.2. BIM Supporting the Architectural Learning Objectives

> "In a fast changing, challenging, and technologically-driven industry, it's more important than ever to build your knowledge and skills to get the job done better and faster."
>
> (Valance et al., 2018)

The current state of the AEC industry implies great technological and institutional transformations along with their correspondent challenges. The industry is adopting new techniques for information. It is sharing and growing concepts of sustainability, BIM, and collaborative technologies. However, there remain limitations for BIM adoption, such as the lack of BIM-trained tutors, which is considered a main barrier to BIM use (Moustaka et al., 2019). Emerging technologies related to sustainability are a new trend that encourages BIM use (Levitt, 2007). New research trends are taking the spot in the AEC industry. These trends are mainly focused on the growing partnerships between the research community and the industry, which occur through technology, collaboration, and sustainable development (Bakens, 1997).

Studies have been conducted across the past few years to determine the technical and personal abilities of young professionals in response to the requirements of the construction industry (Lang et al., 1999; Johnson & Gunderson, 2010). Results demonstrate some concerns that are related to the need to have strong teamwork collaboration skills, broad perspective with the industries' concerns such as those dealing with social, economic, and environmental factors and the need to know how to apply the gained computer skills with engineering science. Graduates of the engineering field must be able to deal with the rapid pace of technological developments within a highly interconnected world. The key is to have a mutual collaboration between the academic and the practical industries which will lead to growth and address concerns related to technological research in the AEC industry (Issa & Anumba, 2007).

Previously, the AEC educational system did not allow for adequate interaction between different disciplines. This issue is becoming worse due to the increase in adopting new project delivery systems like integrated project delivery (Becerik et al., 2010). Keeping the architectural curriculum up to date with the requirements of the industry is a major challenge within the rapid ongoing transformation that the AEC industry is subject to. Yet, the AEC education should be the one who sets the pace rather than the industry through incorporating within its structure the current and future challenges. It should furthermore focus on the collaboration of multi-disciplines since the AEC profession is not limited to one single discipline. AEC educational programs should additionally support new technologies, promote sustainability, and think cross-disciplinary (Becerik et al., 2010).

The goal of the AEC programs focuses on maintaining the standards which enable it to obtain accreditation, yet sometimes limits the tendency to perform any changes on the modules (Sharag-Eldin & Nawari, 2010). The implementation of BIM necessitates the development of new skills which exposes the user to new opportunities. It is important for architectural programs to stay updated with the new technologies and the new associated requirements. Therefore, it is essential to make sure that BIM tools are implemented in a manner that achieves the architectural learning objectives. The Architects Registration Board UK set the criteria for an architectural education part 1 and part 2 and are elaborated in the QAA benchmark document as follows:

The first criteria is represented in creating a design that combines both the aesthetic and technical requirements, which can be translated through BIM. The second criteria is related to having the basis and background of historical and theoretical knowledge in arts and architecture. Having knowledge in urban design and planning, along their associated skills, comes thirdly and are therefore reflected in the use of BIM. Understanding the relationship between the building, the users, and the environment acts as one criteria, too. When incorporating BIM into these criteria, it is strongly reflected in the urban modelling aspect and the acquired skills (Moustaka et al., 2019).

Any design project starts with a preparation process followed by investigation methods. Understanding the structure of the building is one important feature since it might convey possible executional or engineering problems. The role of BIM adoption is to highlight potential design errors and record all materials and details. The criteria for having the building data along with the physical problems and the building's function are aided with BIM. The BIM system allows to perform multiple analysis techniques on the building's model in order to test it against several factors. Cost analysis techniques are one criteria in BIM models. Finally, the process of BIM produces one building model that respects the regulations and organizations involved in transforming conceptual designs into fully integrated BIM plans (Coates et al. 2018).

Based on the previously discussed criteria, core knowledge shall be developed at undergraduate architectural level. Students shall demonstrate procedural knowledge through assessments of the architectural programs. Architectural practices act as a major input in defining the architectural program (Coates et al., 2018).

2.9.3. The Case of the BIM Academic Forum

With BIM emerging as a growing priority in different countries, the need for guidance to implement BIM in the AEC industry is vital academically and professionally. BIM forums, which support the implementation of BIM in the academic curriculum in parallel to the changing needs of the industry, were seen in leading countries that adopted BIM. Among these is the BIM Academic Forum (BAF) in the UK, established in 2011 in response to the academic needs of BIM. The BAF consists of a group of educators from different UK universities along with the BIM task group. The mission of this forum is to support and promote BIM activities from training, learning, to research through strong collaboration between BIM professionals (thebimhub, 2015).

In the UK case, the BAF has developed a framework for implementing BIM across universities (BIM Academic Forum, 2013). The focus of the BAF was to develop a framework with a set of BIM learning outcomes that should be updated within the UK universities. The developed framework was still flexible in terms of adopting BIM where each university shall consider its own approach when embedding BIM within its curriculum.

Level	Understanding Knowledge	Practical Skills	Transferable Skills
4	Improve collaboration In the business of BIM	Introduction to technology used across disciplines	BIM as Process/Technology/ People/policy
5	BIM concept – construction processes Stakeholders' business drivers Supply chain integration	Use of visual representation BIM tools and application Attributes of a BIM system	Value, lifecycle and sustainability 'Software as service' platforms for projects Collaborative working Communication within inter-disciplinary teams
6	BIM across the disciplines Contractual and legal frameworks/regulation People/change management	Technical know-how: Structures and materials Sustainability	Process/Management How to deliver projects using BIM Information and data flows BIM Protocols/EIR

Table 2-4 BAF Learning Outcomes in UK Curriculums (Source: BAF, 2013)

The structure of the architectural undergraduate course in the UK is based on a 3-year program curriculum. Therefore, the development of a BIM framework with BIM learning outcomes was tailored to fit the three academic levels 4, 5, and 6. The ultimate focus throughout those years is to achieve learning outcomes on three main aspects: understanding knowledge, practical, and transferable skills. As shown in the above figure, "level 4" of year 1 motivates the students to understand the importance of BIM within the AEC business industry and know the new tools associated with BIM introduction across disciplines, which allows them to gain practical skills. Moreover, students have the chance to know the overall process of BIM and how the data is prepared and shared across people. “Level 5” of year 2 details more the role of BIM within the business industry. It additionally witnesses practical application of BIM tools that strengthen the student’s visual representation skills. Students get to experience the advantages and value of BIM in a collaborative working environment. The final level of year 3 aims at supporting the students in understanding contractual and managerial BIM-related knowledge. It deals with the practical skills related to structures and materials. Finally, it focuses on how to deliver a complete BIM project (BAF, 2013).

2.9.4. Global overview of the BIM Implementation

One of the global overviews about the implementation of BIM within the architectural curriculum can be found in Barison and Santos (2010) study, which reviewed 25 architectural programs in different universities across the world. The study concluded that only 6 out of 25 universities taught BIM at an introductory level. 12 out of 25 universities taught BIM at an intermediate level, which leaves only 7 out of 25 universities teaching BIM at an advanced level. Moving closely to each level, BIM at the introductory level did not require any pre-requisite courses such as CAD computer skills, which definitely made it suitable for the implementation at the first year level.

The study, moreover, highlighted the idea of learning BIM through distance collaboration. The concept is becoming a favorable option since it simulates a realistic collaboration among students from different universities across the world. For instance, the faculties of architectural engineering at the University of Nebraska-Lincoln and University of Wyoming have already implemented this approach. Another collaboration was recorded between students of different levels at Virginia Tech and University of Southern California, who shared on a platform a common course related to construction engineering management (Becerik-Gerber et al., 2012). In the UK, a similar concept for a BIM hub was adopted internationally between Loughborough University and Coventry University in the UK with Ryerson University in Canada (Poh et al., 2014), a further discussion about the UK case will be in a separate section.

As with any new material, teaching BIM imposes some challenges, yet some opportunities as well. In the study of Becerik-Gerber, et al. (2011), more than 100 US-based programs related to the AEC industry were examined. These programs showed irregularities in the acceptance and adoption of BIM across different institutions, which are closely associated with differences related to educational, cultural, and economic factors. Challenges in BIM adoption within the curriculum can be seen in the ability to withstand the adoption of BIM elective courses, especially within an inflexible time frame due to graduation requirements or lack of teaching material references (Sabongi, 2009). However, managing to implement a BIM-related dissertation course can add value and strengthen in-depth skills for undergraduates (Azhar et al., 2010).

The attempt to assess and analyze BIM adoption in the curriculums was examined by Pikas et al. (2013), who identified 39 key topics for the competencies of BIM which should be developed by construction management students to apply later on in the industry. One example for teaching BIM to graduate students is the approach selected by Wang and Leite (2014), where it covers different topics, such as cost estimation, scheduling, 4D simulation, 3D point clouds, MEP design coordination, and energy simulation. It is no doubt that the revolutionary technology of BIM is creating different types of activities that go beyond the traditional roles in the AEC industry and imply re-definition and creation of new job opportunities and titles, such as model manager, BIM manager, BIM engineer, and BIM coordinator (RIBA, 2012). Hence, implementing BIM in the existing architectural curriculum shall result in similar new professional titles. Yet, there is no indication that separate BIM degree programs are obligatory to target these new oriented BIM professions.

In general, in order to ensure that the instructing and learning process approach are effective, a combination of methods might be used, such as: lectures, collaborative learning, practice, narrative videos, problem-based and self-study methods as discussed in the principles of “how to learn” by Bransford, et al. (2000). Therefore, learning BIM can be attained through traditional instructors teaching methods or problem-based projects and video tutorials. It is advised by several researchers that self-learning through video tutorials helps students acquire BIM skills not only on their own, but increases as well the stimulation, knowledge retention, satisfaction, and problem-based learning for students (Chan, et al., 2010)(Choi and Johnson, 2007).

Several architectural engineering schools have taken the approach of adopting BIM within their curriculums in different parts of the world.

The implementation of BIM in various countries was assessed in a survey conducted by NATSPEC in 2013 to be later re-assessed in 2019. The results reflect the status of BIM awareness and implementation in the educational sector at levels across the world. Below is a summarized overview on different countries in the approach of BIM in education (NATSPEC, 2019).

d) Australia

11 out of 30 accredited institutions in Australia have successfully shown a great uptake to BIM within their undergraduate architectural programs, even though it has been on a basic introductory level. The chosen methods for BIM implementation in the curriculum were either through covering theoretical concepts related to BIM or through teaching the basic uses of BIM as a software. Technical colleges have likewise incorporated BIM into the syllabus through the use of specific BIM software packages.

e) Finland

One of the world’s leading examples for BIM adoption is in Finland, where the Universities of Applied Sciences (UAS) and Vocational Education Institutes provide BIM education within their construction and architectural courses for students making the inclusion of BIM in their professional courses. The content of the AEC programs is enriched with different BIM-related courses (standalone approach) and some of the UAS already provide a bachelor degree in Architecture, where the key areas of focus in the undergraduate study plan are BIM and model utilization. Furthermore, some Vocational Education Institutes provide ongoing BIM education for postgraduates such as: CAD-BIM utilization for HVAC on construction sites.

Among the other initiatives for BIM adoption were the use of national and international guidelines such as: COBIM, Finnish XML, ROTI 2019 Report.

f) Netherlands

The different educational institutions of Netherlands have witnessed an uprise in BIM adoption for the past years. For instance, the three technical universities of Netherlands have all adopted BIM in its taught courses at the undergraduate and postgraduate levels, mainly as standalone courses.

g) New Zealand

Construction courses in most tertiary institutions in New Zealand have been integrating BIM within its course content where most of the universities already have a BIM-based research approach. In parallel, software vendors are providing BIM training to ensure the minimum knowledge for students upon graduation.

h) Norway

The attempt to implement BIM in education in Norway goes back to personal efforts from a number of engaged teachers, who are driving open BIM education across universities and colleges in support of building SMART Norway (bSN). There are a minimum of seven faculties who are using open BIM courses and multiple colleges already have specific BIM studies. Building SMART

Norway are putting pressure on faculties on the government to adopt BIM and have released an educational program in 2014, which acts as a teaching plan. The program shall be based on core courses and three role-specific courses for the engineers, contractors and clients. These courses are unrelated to major programs and provide them with the BIM theoretical knowledge. Moreover, the suggested educational program allows students to take an exam and obtain a BIM certification documenting their skills.

Later in 2015, bSN issued the BIM Guideline database, which enables clients to specify requirements for BIM deliveries without the need of having a specialty in BIM expertise within the organization.

On the governmental level, municipalities and legislative bodies are aware of the need for shifting towards digitalization. The Building Authority already supports different initiatives in collaboration with the industry. Hundreds of projects are making benefit of openBIM, such as "New Østfold Hospital" as a large-scale openBIM award winning project. The upcoming frontier for the government is to expand digitalization to include construction product information and FM/operational documentation.

i) Implementation of BIM within the AEC Education in the UK

The implementation of BIM in the UK curriculums has encountered some shortage in the pedagogical literature, the case studies regarding how to develop the curriculum and the respective experiences in teaching.

The implementation approach adopted by McGough, et al. (2013), was a two-staged one used to integrate BIM in multi-disciplinary departments of Coventry University. The approach incorporated the implicit introduction of collaborative working skills to first-year students and the reorganization of a third-year integrated project module. Another case is Eadie, et al. (2014) implementation approach, which supports BIM adoption through standalone modules linked to other AEC courses in a multi-disciplinary department, where both theory and software-related aspects of the built environment are taught. Nonetheless, the

BIM Academic Forum (BAF) stands in an important position in coordinating with over 30 universities in the UK regarding its BIM academic framework. One major guideline is a report which deals with BIM embedment in taught programs, sponsored by the UK's Higher Education Academy (HEA, 2013). The report outlines BIM impacts on the needs of the students and the respective level of experience of the tutors in relation to the learning objectives and outcomes. The report defines three types of desired BIM learning outcomes: knowledge and understanding, practical skills, and transferable skills. Ghosh, et al (2013) likewise supported the categories of learning outcomes, where he discussed how the effectiveness of BIM implementation is related to the pedagogical approach that should cover theory, practical experience, and use of technology-driven collaborative environments.

However, the report remains silent on some issues which are related to the practical bearing on successful BIM integration. One of these issues is that the report does not discuss the importance of role-playing among the students of multi-disciplines as a pre-requisite to the skills and knowledge to be gained at BIM level 2. The professional tasks of the collaborative work of BIM modelling should follow a sequential order and should be adopted by students in the form of role-playing (Shafiq, et al. 2013. Gu and London 2010). This is demonstrated in Becerik-Gerber et al. (2012) who sees that role-playing is helpful when acquiring new skills and therefore contributes to effective collaboration with respect to the UK's Level 2 BIM ambitions.

Generally, when teaching BIM, the contexts of sustainability and whole life cycle performance of the building are both a main consideration. In the UK, the main focus was to achieve the target set in implementing BIM as per the Construction-2025 strategy document (Cable et al. 2013). This strategy aims to achieve a 50% reduction in greenhouse gas emissions and a 33% reduction in whole lifecycle costs.

The most effective BIM programs in the UK are seen in postgraduate university taught programs. Yet, it is unclear why undergraduate courses haven't adopted BIM in the same way. Nevertheless, the UK universities which implemented BIM in their post-graduate courses have focused on specialization with evidence of using distance learning as the most desired tool for delivery, if not the only one. Such MSc distance learning approach is favored for offering the opportunity for AEC professionals to up-skill themselves in BIM education and progress in their career (Khosrowshahi et al., 2012).

Therefore, it is likely for universities to offer similar modules in the distance learning mode of delivery or in the disruptive innovation mode in teaching which aims to assist students and allow them to learn new skills in a flexible manner regarding when and how learning content is delivered to them, in addition to the affordability of the such method (Christensen et al., 2011). Hence, the web-based disruptive learning models for BIM-based courses would want to consider persistence, which is a pedagogical phenomenon that defines the skills, behavior, and attitude needed for the student to complete an online-based course (Hart, 2012).

BIM as a specialization might be more marketable as per the findings of Khosrowshahi et al. (2012), which means that the demand for acquiring BIM skills and certifications would drive changes within the organization and therefore lead to career progress. Here, a risk is present in this approach where BIM might be considered as a specialization rather than a fundamental process for collaborative design.

One popular model for disruptive innovation at the level of higher education is Massive Open Online Courses, which are motivating universities to rethink their learning program approach (Kartensi, 2013). Several benefits support the Massive Open Online Courses (MOOC) use, such as empowering participants to acquire learning abilities and computer skills, expanding the capacity to quickly engage in the innovative technology world, and permitting universities to test the effectiveness of new curriculum approaches (Kartensi, 2013).

The concept of online learning is often belittled due to concerns linked to the distance involved and the quality of online teaching, which may be different from the real quality obtained at universities. Hence, MOOCs are sometimes viewed as the old-fashioned 'correspondence courses' (Kartensi, 2013). On the aspect of finance, the high tuition fees in the UK are considered an important factor in the criteria for selecting a university (Dunnett, et al. 2012). Evidence shows that UK students are considering options, such as studying in public or non-profitable institutions or studying within or outside the UK (Dunnett, et al. 2012). Therefore, the rising popularity of MOOCs is compared to the high costs of the degrees. Studies reveal that the future of BIM education is specifically reflected on the postgraduate level. Suggestions recommend options, such as the alternatives to traditional campus learning, BIM upskilling for better career progression, and shift towards consumer-like approach in benefiting from their learning experiences.

2.9.5. Implementation of BIM within the AEC Education in Lebanon

This section represents one of the major gaps since no clear data is available within the limited architectural faculties in Lebanon. The data retrieved in upcoming sections are from the experience of professionals and educators that reflect the current situation and come up with solutions.

2.9.6. Barriers of BIM Implementation within the Curriculum

The main barriers to the implementation of BIM within the architectural curriculum are related to the following:

1. The lack of the suitable staff to teach BIM is mainly due to the high demand on BIM experts, where the faculty may not be able to hire a new member who has been trained extensively with BIM in their educational or practical experience (Pereiro et al ., 2018; Ghosh et al., 2015l; Becerik-Gerber et al., 2011; Pikas et al., 2013). For the existing teaching staff, especially at the senior level, BIM is a new technology which requires great effort and loads of time to be proficient with the tool. It takes a long period within the framework of the faculty's curriculum to adjust to the changes resulting from BIM adoption (Becerik-

Gerber et al., 2011). For several programs that are teaching-oriented, the number of full-time faculty tutors is usually small and they mostly work in a full-time mode between teaching and advising. It is specifically hard for them to have the time to develop and teach these new BIM-related topics.

2. The lack of a student's knowledge of BIM is another barrier. (Pereiro et al., 2018; Ghosh et al., 2015). The learning curve of BIM is steep compared to the traditional drafting tool of CAD (Zhao et al., 2011). It is more challenging for students to self-learn BIM without any guidance (Chen et al., 2011). Students who have previous exposure to CAD may experience some difficulties transitioning to BIM. Moreover, students without a clear understanding regarding the systems of construction may similarly experience a variety of challenges when using BIM (Zhao et al 2011; Ghosh et al 2013).
3. The biggest challenge for BIM adoption in curriculum courses is that there is really no room for it (Pikas et al 2013; Ghosh et al., 2015; Sacks et al., 2013). The majority of architectural curriculums are already loaded into a complete system where there is no space to add any BIM technology-related courses. Moreover, the consideration that students can enroll into BIM courses beyond the university scope leads is somehow neglecting its necessity to be added into the university curriculum (Becerik-Gerber et al., 2011)
4. The lack of interest and willingness in the faculty to teach BIM is a barrier (Sabongi 2009; Ghosh et al., 2015; Sacks et al., 2013; Becerik-Gerber et al., 2011; Gier et al 2015; Lee et al., 2013). This is mainly due to the effort and resources necessary to change the current curriculum, which is already sufficient with its materials (Sabongi, 2009). Also, in order to attain a professional level in BIM, repetition and practice are useful. This is difficult to achieve in existing lecture-lab settings with a limited time frame (Gier, 2015). The technical skills of BIM sometimes take time to cover them within a bounded time remaining for their application (Glick et al., 2011)

5. The criteria in the ACCE and ABET for accreditation do not mention any requirement for BIM use (Pikas et al. 2013; Ghosh et al 2015; Becerik-Gerber et al. 2011). Since most programs are accredited by these institutions, then they are not imposed by any obligation for BIM adoption in the courses. The current application of BIM components in the curriculum are in the category of computer applications or information technology (Ghosh et al. 2013). In the absence of any form of accreditation requirements, some architectural programs lack the motivation for BIM incorporation.
6. The demand for BIM professionals in the AEC industry is high, yet it is vague what BIM skills are expected to be found in graduates (Sacks et al., 2013). Furthermore, the lack of teaching resources, such as tutorials, textbooks, and models to teach BIM was a main issue in the introduction of BIM to the architectural program a decade ago (Pikas et al., 2013; Ghosh et al 2013; Ghosh et al., 2015; Sacks et al., 2013). However, after a period of 10 years of BIM development, this challenge is no longer there since various resources are authored and many AEC institutions have shared their models and projects with the architectural programs that showed interest in BIM introduction to the curriculum.

2.9.7. Current Strategies of BIM Implementation

The implementation of BIM within architectural programs has progressed in different forms: developing new BIM-oriented single courses to include what could not be integrated within existing courses (Ghosh et al., 2015), embedding BIM within existing courses where possible (Zheng et al., 2016), and through organizing seminars and workshops (Gledson et al., 2017; Olowa et al., 2019).

a) Stand-Alone BIM Classes

BIM as a stand-alone course is commonly taught as a 3D-modelling software in the form of Revit. As mentioned previously, the approach to teaching BIM as a stand-alone course started in the USA back in the middle of the 1990's

(Sampaio et al., 2015; Barison et al., 2010a, 2010b). A bigger attempt to implement BIM was in NSW University in Australia, where BIM was implemented in three stand-alone modules: Computer-aided design, building information modelling, and advanced techniques which help students in developing their modelling skills through mastering BIM tools (Brewer et al., 2012). Gerber et al. (2015) recorded the use of BIM in undergraduate and post-graduate architectural programs in the USA. Results illustrate that BIM core courses are higher than elective courses at the level of an undergraduate program. While at the level of the post-graduate program, BIM elective courses are higher than the core courses of the program.

The issue that is detected from implementing BIM as a stand-alone course relies on the feature of BIM-achieving collaboration between multiple disciplines. The fact that BIM is applied on single courses does not allow the achievement of this level of collaboration (Almutiri, 2016). The solution relies on embedding BIM in the design studio for an in-depth practical application, instead of limiting it to delivering BIM tools in separate courses.

b) Integrated-Design Studio using BIM

When BIM is integrated in the design studio, which is the core structure of the architectural program, at every year, students tend to understand the workflow better in a more realistic approach to the AEC industry and develop their knowledge in the Integrated Design Studio (Jurado et al., 2017). The IDS concept was initially introduced at Penn-State University in the USA back in 2006 (Mandhar et al., 2013). The method proved that students gained a better understanding and deep knowledge in the project process similar to real life. Consequently, the National Council of Architectural Registration Boards has adopted this method. Ambrose (2012) claims that although BIM was implemented within the Integrated Design Studio in the AEC curriculum, it has not attained the anticipated level of maturity. Regarding Ambrose's point of view, what is needed is for universities to support the collaborative approach of BIM application through the use of multiple-teaching techniques, such as:

interdisciplinary, multi-disciplinary, trans-disciplinary, and distance-collaboration. Although the techniques might seem quite similar, the difference relies in how the problem is posed. For instance, in the interdisciplinary approach, the design problem is introduced to all students in the design studio; whereas in the multi-disciplinary approach, the design problem will be introduced to one discipline (mainly the architectural discipline), who will, in turn, take charge in discussing the problem. This is similar to the working environment where the architect takes charge of coordinating between all disciplines and presents design solutions to problems (Aarts et al., 2014). In the case of trans-disciplinary, upper-level students engage with either inter or multi-disciplinary teams in suggesting a solution (Repko, 2012).

It is advised that BIM adoption methods combine both the stand-alone courses and the integrated ones in the architecture program. Whatever implementation approaches the institution, the simulation of real-life project life cycle through BIM tools at the educational level shall have a significant growth in the level of BIM knowledge and understanding, enhance collaboration, and improve BIM skills (Almutiri, 2016).

The ideal process for implementing BIM can be summarized based on different researchers input. The first step in the process is the introduction of BIM as a stand-alone software, which teaches students the mandatory skills and tools to develop their work. Next, BIM practiced in the design studio on small projects shall allow them to gain experience and understanding of the project scope (Mandhar & Mandhar, 2013). After that, the scale is shifted towards a more complex large project for deeper insight and knowledge (Barison et al., 2010b).

Successful examples that have taken this approach are the George Institute of Technology in the USA, where students receive a short introduction to BIM through a stand-alone course; then they apply the acquired BIM tools in the design studio (Ibrahim, 2007). The recommendation of Kocaturk & Kiviniemi (2013) was based on the concept of implementing BIM in the first year of the architectural undergraduate program through at least two classes and an integrated design studio. This immensely impacts students by having them learn quickly how to do a model that translates their ideas in the first place, link the information on the model, and share it through the design studio.

2.10. Findings of the Literature Review

At the end of the process of collecting data in the literature review, the aim is focused on identifying the gaps that were missing in previous researches and thus promote the level of knowledge and research in BIM. The major findings of this research can be highlighted as follows:

- BIM, by definition, was an area of interest for individual researchers and institutions. The definition of BIM is not unique but exceptional with its functions and the wide tools it offers. The definition of BIM mainly evolved around its use of information technology in data collection, being a computer-aided graphical tool for visual representations, and generating simulation models for analysis and calculation. (Section 2.2)
- When comparing the requirements of the industry to the delivered outcomes, the traditional teaching methods in the architecture program turn to be inefficient. (Section 2.5)
- BIM is a revolutionary technology that has gained high interest by the market's stakeholders, yet it still lacks the full awareness and implementation in the professional industry and the educational curriculum. This, in particular, stands as the main cause for the gap formulation when shifting from the university to the practical working field. (Section 2.5)
- BIM capabilities rely in the integration between multiple systems to detect any possible errors prior construction and thus mitigate risks, financial losses and waste of time. (Section 2.4)
- The case of the BIM Academic Forum offers universities flexibility and consistency when implementing BIM across different academic levels. The existence of a clear BIM framework sets a clear vision of what to

expect, as a learning output, at the end of each academic level. (Section 2.9)

BIM serves as a multi-tool that offers great benefits in several areas, for instance:

- BIM serves as an information-capturing tool offering better analysis and modelling for projects with a startup of information collection about the context, which could be supported by other tools, such as laser survey and photogrammetry. (Section 2.4)
- BIM serves as an authoring tool creating spaces and detailed elements which are linked to data information properties. (Section 2.4)
- BIM, as an analysis tool, links graphical objects with assigned data which can be used for different forms of analysis that answer several concerns, such as structural analysis, energy analysis, GIS integration, and scheduling of ordering equipment. Moreover, it is efficient as a prototyping tool for urban projects. (Section 2.4)
- Incorporating BIM into sustainability is of great efficiency and advantage, where energy analysis can be performed and the building's effectiveness can be determined. (Section 2.4)
- BIM acts as a communication and visual tool where the generated output from the model analysis helps in evaluating the quality of design and technical and statutory compliance. This therefore allows the visualization of the actual replica of the building, which carefully considers the user experience and the operation of the building. (Section 2.4)
- BIM stands as a manufacturing tool where it is important for a manufacturing business to deliver BIM-based objects that incorporate specifications which boost the business and deliver smart BIM-based objects can certainly boost the business. (Section 2.4)
- BIM, as a management tool, aids project managers in planning the project's whole lifecycle. (Section 2.4)

- BIM, as a collaborative tool, is important in professional practice since it is a requirement nowadays and ensures clear communication between all the project's stakeholders. (Section 2.4)

The assessment of the implementation of BIM within the AEC industry shows that the level of awareness of BIM is high across different countries and it is on an increasing demand in the market. Yet, the rate of actual implementation of BIM is lower than desired.

- The main barriers to implementing BIM are: the associated implementation cost, the lack of skilled personnel, and organizational and legal issues. A clear general standard regarding the implementation and use of BIM is not present, yet. (Section 2.5)

The assessment of BIM implementation in the architectural curriculum shows that the approach is more towards the stand-alone courses than the integrated approach. It is advised that BIM adoption methods combine both approaches in the program of architecture, especially within the domination of the design studio courses in its structure. (Section 2.10)

A parallel collaboration between the academic and the practical industries needs to be ensured in order to better prepare the graduates. Architectural practices act as major inputs in defining the architectural program and should therefore set the pace for AEC education to incorporate BIM. (Section 2.10)

The adoption of BIM in the architectural education is faced by barriers mainly concerned with: the resistance to change, the fully-loaded curriculum which leaves minor space for the implementation of BIM, the training necessary for tutors, the absence of a clear guide for implementation, and the lack of any accreditation requirements. (Section 2.10)

2.11. Summary

BIM is perceived as a dominant innovative tool and a collaborative process for the current era of architectural and engineering practices. The industry has witnessed a growing approach in the implementation of BIM in the AEC industry, which was reflected in its adoption of undergraduate architectural curriculums. BIM has gained different definitions by researchers according to its use, whether as a tool, system, model, or for operation purposes. The benefits of BIM are wide and are mainly outlined in the significant decrease in the initial and total life cycle cost analysis, the reduction of the project's time, the decrease in the wastage of material, the detection of clashes on the BIM model, the efficient collaboration between the project's stakeholders, better visualization of the project, and the improvement of the whole life asset of the project up until the operation and maintenance phase.

The capabilities of BIM are illustrated as: a tool to capture information and input the data on a 3D model, an authoring tool that links the 3D mass with the corresponding information, a tool to analyze different factors affecting the building such as structure and environment, a prototyping and manufacturing tool that aids in the production of models and building components, a sustainable tool for assessing the efficiency of the building in terms of sustainable considerations, a communication tool between the project's stakeholders, a visualization tool for the interior, exterior, and systems of the building. In addition, its major role in the field of practice and management where it achieves better quality control and optimizes the operation of the building.

Moreover, the chapter assessed the current situation of BIM in the AEC industry where different countries have recorded varied percentages in the level of awareness and BIM implementation approach, with a big focus on the case of the UK, as a prominent case regarding implementation. The Lebanese studies concerning BIM and its implementation are still a gap in the literature review and will be covered in a later section. Furthermore, the barriers are discussed and majorly concerned with the absence of accreditation requirements by institutions or governments; the time and money required to train personnel and update hardware, and the absence of a standard framework that guides and supports the implementation of BIM.

BIM, in architectural education, is thoroughly examined through: the architectural institutions approach in implementation as a stand-alone course or within the design modules, the status of BIM in the UK architectural curriculums, the existence of BIM in the curriculum structure in Lebanese architectural faculties, the importance of developing BIM-related skills starting from the undergraduate level, and its reflection on the practical field. Finally, the introduction of BIM within the architectural curriculum in compliance with the learning objectives.

Chapter 3 **BIM IN LEBANON**

This chapter provides additional materials that cover the missing data about the Lebanese situations of BIM in the industry and academia.

3.1. BIM Situation in Lebanon – Collected Data

3.1.1. Data Analysis

The analysis of the collected data in Lebanon was divided into two main categories: BIM in the AEC industry in Lebanon and BIM in the education sector in Lebanon; two core points are assessed in each case. The first one is concerned with BIM awareness by the participant, and the second one examines how far BIM is implemented in the companies for the professional field case or in the universities for the academic field. The categories are represented in the below diagram.

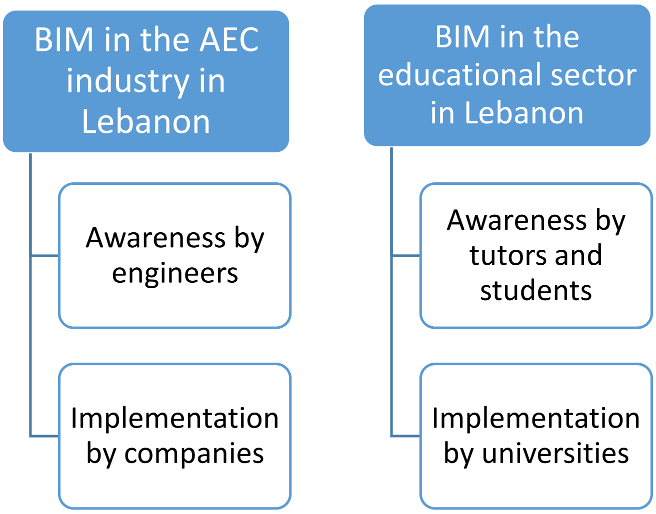


Figure 3-1 Analysis of the Data Collection in Lebanon

In an attempt to develop a BIM implementation framework to be specifically adopted in Lebanon and generally in other countries, it is essential to locate the existing situation of BIM awareness and implementation in both the academic and practical fields.

BIM in Lebanon is explored within the AEC industry on the one hand, and within the educational sector on the other hand. In each sector, the awareness of its participants is assessed in order to evaluate to what extent they are fully aware of BIM and to further assess the implementation of BIM in relation to the awareness results. For instance, the level of BIM awareness for engineer practitioners in the AEC practical field is assessed in parallel to BIM adoption levels in companies. For academic tutors and students, the level of BIM awareness is furthermore assessed in relation to the consideration of BIM within the architectural curriculum. A detailed analysis for each category is developed below.

a) BIM Awareness in the AEC Industry in Lebanon

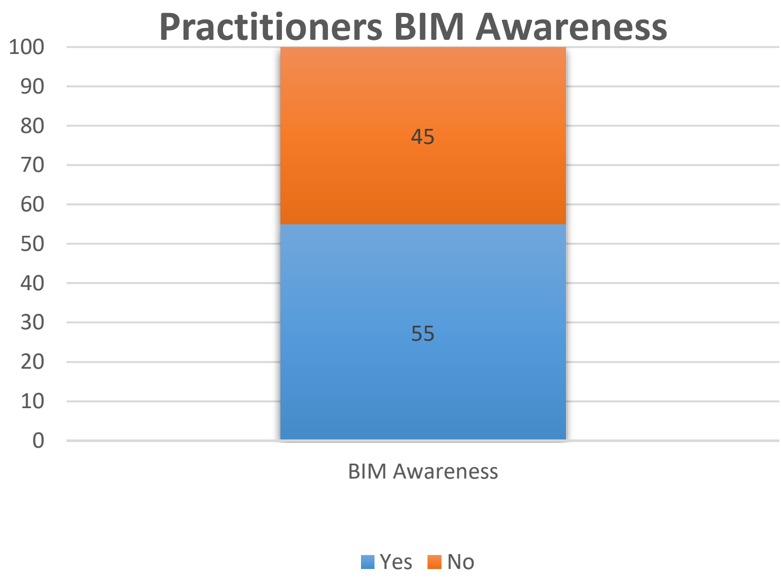


Figure 3-2 BIM Awareness by Practitioners in the AEC industry

To assess the scale of the existing problem in implementing BIM, the level of BIM awareness in the practical AEC industry must be identified. The basic introductory section in all semi-structured interviews starts with exploring the participants' background. The key is to identify the number of participants who were aware of the BIM system in the first place. The results of the semi-structured interviews with the practitioners came to demonstrate that 55% of the engineers are aware of BIM systems, while 45% are unaware of it. The majority of the 55% belong to participants who are working in institutions that are ranked as medium-large-scale companies. As part of the company's enhancement of quality, all employees were subject to BIM training as a system and software. This procedure was obligatory in order to involve them under the newly-established BIM department. Furthermore, trained employees had to work and coordinate with other team members who has expertise in BIM. The first group of employees belonged to the category of old employees. BIM training was imposed by the company as a requirement to maintain specific posts such as senior engineers. The training was also a prerequisite for junior engineers joining the company, where they had to be aware of the capabilities of the BIM system. The second group of employees did not receive BIM training by the company, even though it was an obligation for them to acquire BIM skills, yet they managed to get external training from tutors in order to secure their jobs and meet the new requirements during a specific period of time. Learning BIM on a tight timeframe was a challenge for both groups, for they needed to practice while learning and shift to the new system immediately. The third group of employees represented about 10% of the practitioners who gained BIM skills at the level of university since it was part of the curriculum back then or during their postgraduate studies abroad.

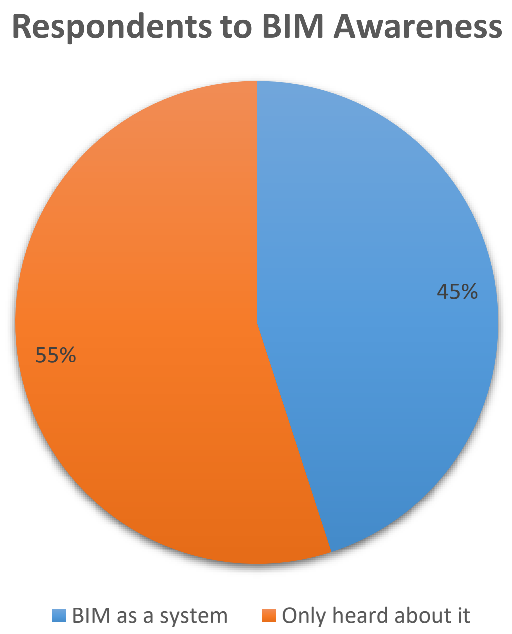


Figure 3-3 Practitioners being Aware of BIM

Going into the 55% who recorded BIM awareness, 45% were aware of the system itself where the rest only knew of its existence as a concept or have only heard of it as shown in the pie chart below. The ways through which respondents were aware of BIM are varied. For the first group of respondents who recorded their good awareness of BIM, the main methods were training received by the company/institution or through self-efforts, workshops, and seminars. As for the second group, who knew BIM as a concept, got their general awareness through colleagues, emails, newsletters, and social media platforms. Therefore, the level of BIM awareness is related to the method of BIM introduction.

The results suggest that great effort is to be made to introduce BIM to professionals and ensure they understand it as a system. A BIM concept is understood when it is presented through advertising media or discussions with professionals or users. The introduction of BIM through practice, seminars, workshops, and presentations performed for engineering companies or hubs allows better understanding of it as a system and opens the opportunity for wide discussions about the capabilities of this system. Therefore, when BIM is promoted using correct means and to the targeted end users, the level of its awareness increases.

b) The Implementation of BIM within the AEC Industry in Lebanon

The second question related to the background of the participant is related to the implementation of BIM by the working institution. 52% recorded they know BIM through their experience in their working environment, while the rest are aware of it but have no implementation history in their working environment or they have implemented it through their freelance work beyond their companies.

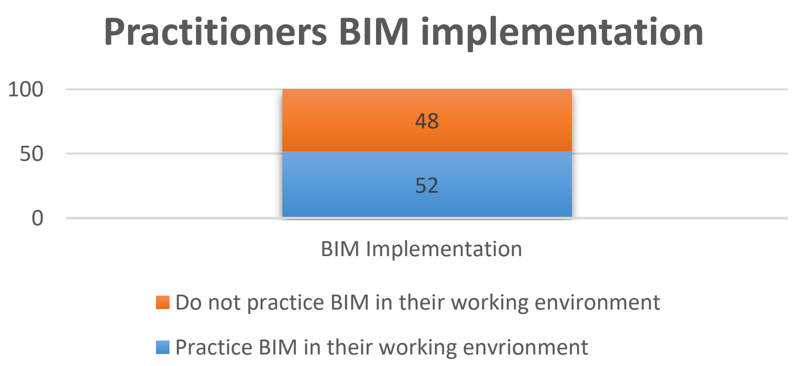


Figure 3-4 The implementation of BIM in the AEC industry

When exploring more the motivators for the implementation of BIM, several reasons can be detected as opportunities. The fact that the majority of the companies that are implementing BIM are medium to large scale companies means that they get to be exposed to projects beyond Lebanon, especially in the Gulf region and KSA. This imposes two major things on the companies: the requirement of BIM use by their clients and the level of competition between consulting companies bidding for the proposals, which imply high qualification levels that are up to date with the ongoing technologies.

Respondents have additionally recorded that their experience of BIM in their companies has started with BIM training by their institutions, which explains the need to upgrade the skills level in a large number of companies and therefore prepare the staff for BIM-oriented projects.

BIM implementation within companies starts with motivating the decision makers through presenting BIM benefits and ensuring a smooth implementation process. The adoption of BIM by companies shall guarantee that more practitioners will get the opportunity to learn and do BIM training. In a time where improved quality and high levels of competitiveness mean the involvement of companies in BIM-related projects, managers should then be convinced to change their working scheme to BIM. The chances for companies, who are willing to implement BIM, may increase if they were offered good package deals for the cost of implementation since this may be the main barrier for implementation.

One of the interviewers has also highlighted how external institutions provide BIM training in the form of REVIT, only where there is no accredited certification for professionals who wish to attain a BIM manager title. Therefore, in order for a professional to acquire a certified BIM title specialized in BIM systems or BIM management, one has to attend external programs outside the country or enroll in online programs at an international accredited university. Even if the training is offered by the company where engineers work, the training involves BIM as a REVIT tool solely and not as a whole system.

c) BIM awareness within the educational sector in Lebanon

- **Students**

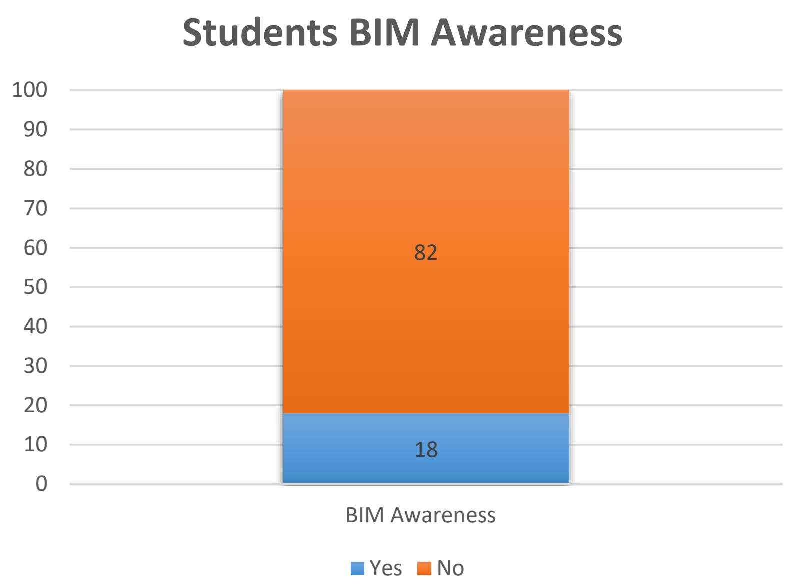


Figure 3-5 BIM awareness by students in the educational sector

The interviewing process with the students involved the participation of 67 students across different universities in Lebanon. The results recorded the following: 12 out of 67 (18%) of the students have the necessary level of BIM awareness, while the rest of them haven't heard of it. The minority of students aware of BIM students were able to define BIM in its general definition. They were able to list most of its capabilities and demonstrate the ability to work within its software. This is shown in their portfolio and university works, but most of them are not yet prepared to the practice; as they didn't perform a practical application for BIM within their curriculum design studio.

The methods in which students got aware of BIM were through their peers in senior levels, who have used BIM as REVIT tool in order to visually present 3D models and renders. These students have managed to learn BIM through video tutorials and self-effort applications or through training at specialized centers. For most, the tutoring of REVIT was not supported in their university and thus the presentation of 3D visualization was the main motivator to go after self-learning option in order to present higher quality of drawings in their design projects and excel among their colleagues. Upon the development and validation of the adequate BIM implementation framework in the architectural curriculums, these results are expected to decrease gradually.

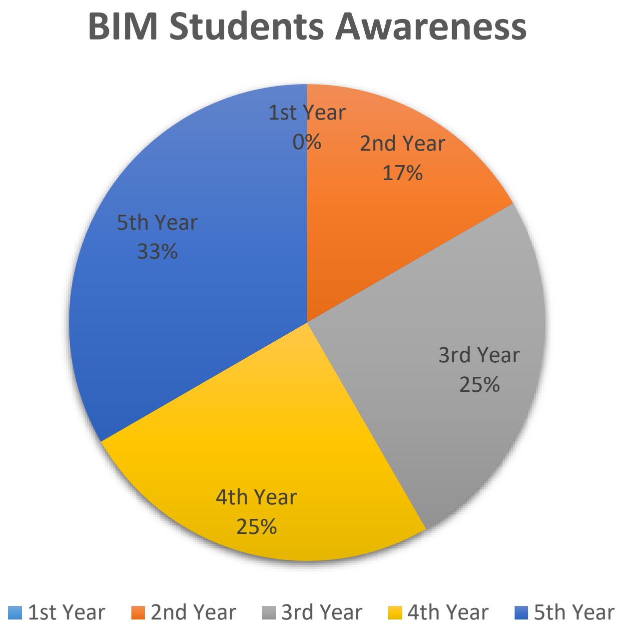


Figure 3-6 BIM awareness by students in the educational sector

When the group of 12 students, who recorded their BIM awareness, was further examined based on their level of education in the curriculum, the results turned out to be as represented in the above pie chart. The preliminary recorded results that reflect the few attempts for BIM adoption in the Lebanese architectural university programs.

It is clear from the marked percentages that BIM awareness is introduced after the first year, to be consistent during the 3 consecutive years ranging from 2nd to 4th year, and finally mark a slight increase in the 5th year. This supports the previous results in figure 31, which suggested that when students need to excel in the presentation of visual 3D material, they tend to search for the software and tools which enable them to achieve these results. Since BIM is the dominant trend, students get to know about it from their senior friends or might have heard of it from tutors who are knowledgeable about BIM. Thus, students have managed to earn BIM skills through self-effort and improved their practical skills by the senior levels.

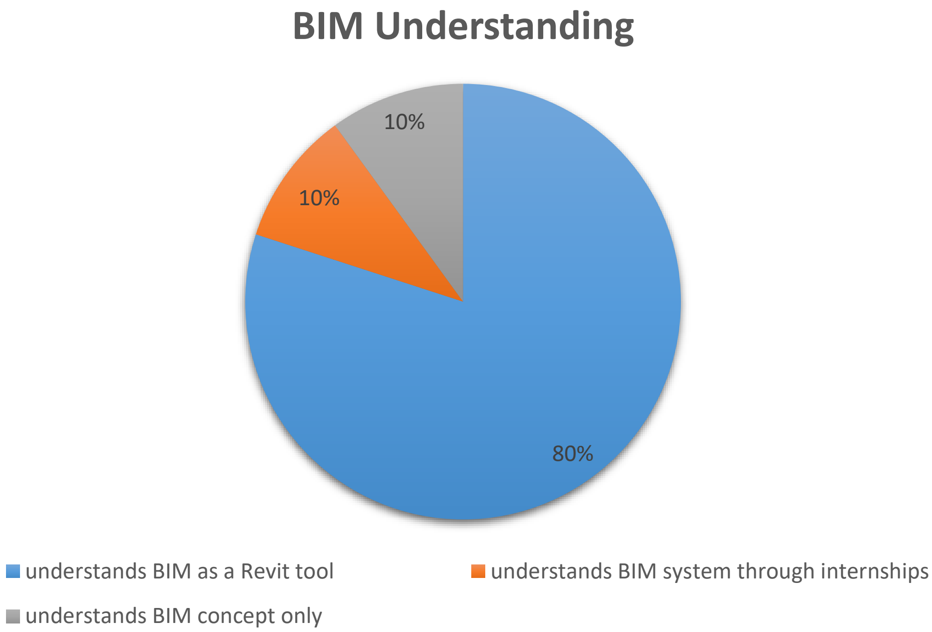


Figure 3-7 BIM understanding by students

When discussing with students their level of BIM awareness, 80% think that BIM is a Revit tool, while the other 10% understand BIM as a system due to their practice internship prior to their senior level and the remaining 10% have heard of it as a concept as represented in the pie chart below.

The concept of BIM is seen differently by students where the majority (80%) understand BIM as a Revit tool. This is due to its limited implementation in the architectural programs as a REVIT single course without any application in design studio courses or inter-connected courses. Meanwhile, 10% of the respondents understand BIM concept only without any practical experience and also another 10% have the correct understanding of BIM as a system due to their personal efforts in internships at companies which deal with BIM.

Moreover, although BIM adoption in different curriculums generally suggests the gradual introduction, yet the above recorded results reflect the amount of effort that is expected to be performed in BIM adoption and reinforced in the implementation framework. The results suggest that though the respondents are aware of BIM, yet, they don't have the same concept of BIM understanding. This could be associated to the numerous BIM definitions that are present in research, which result in the misinterpretation of the core concept and purpose of BIM as a whole system. Moreover, the level of BIM awareness and understanding by tutors impacts the students they teach. This is further explored in the next section.

- **Tutors**

The second part in BIM awareness of the educational sector is concerned with the awareness and understanding of the academic tutors. In Lebanon, 9 universities are accredited to teach the architecture program; therefore the contact list with the academic staff was concerned with these universities where at least 3 educators from each were a part of the research.

To reach as many participants regarding their experience with BIM in the Lebanese curriculum, a short questionnaire was sent via email or conducted at the office with the candidates who ranged between tutors and assistants. The questionnaire was based on two questions. The first one is concerned with the personal BIM knowledge and the second one focuses on the implementation of BIM within the architectural curriculum of the institution.

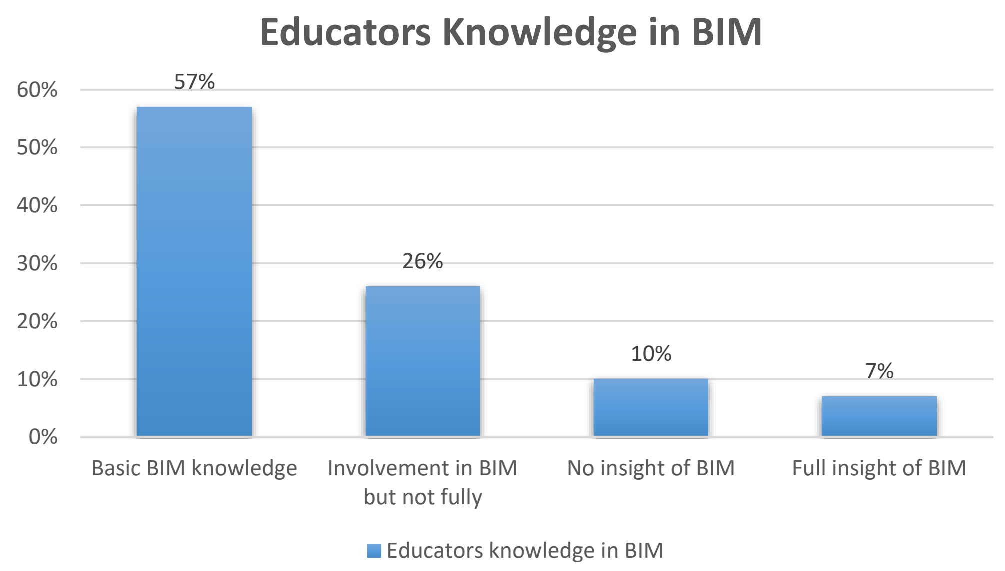


Figure 3-8 Diagram showing the educators BIM knowledge percentages

The results came to illustrate that around 57% of the educators have a basic knowledge regarding BIM, 26% of the educators are more involved in BIM knowledge but not as a full system, 10% had no insight at all regarding BIM and only 7% were fully aware of BIM system through their professional background or their practice of BIM tutoring as Revit courses. The results explain the limited implementation of BIM in the architectural programs since the majority of the teaching staff have either no insight into BIM or a basic knowledge of BIM. Hence, how could students be taught BIM if the understanding, knowledge, and experience of BIM was not enhanced by their tutors in the first place?

The development of the BIM implementation framework shall take into consideration the hierarchy in education and teaching when implementing BIM. For instance, the adoption of BIM should be accepted by the decision taker in the educational institution as a first step. The second step is the training of tutors on BIM and the assignment of BIM technicians. When the teaching staff has fully understood BIM aspects, then the implementation in teaching students shall commence in parallel with the update in the curriculum to involve BIM.

d) The Implementation of BIM within the Educational Sector in Lebanon

The assessment of the architectural curriculum in Lebanon involved the examination of the undergraduate program curriculum of 9 accredited universities for teaching the architectural program. The undergraduate program of each university was examined in detail across the five years based on its structure, content, and credit hours. The core category for all universities is the architectural design studio, which starts from the first semester and ends in the fifth year with the graduation project. The introduction of engineering construction courses varies across universities, where 7 out of 9 universities start with construction-related courses from the first semester of the first year. The distribution of theoretical and history courses varies widely between universities. Courses that teach manual and digital skills reflect different distributions from one university to another. Management, Law, Management and Sustainability courses are of different interests at each university. Finally, the portion dedicated to general electives and university courses varies widely across universities.

The table below details the components of each curriculum at each university, which are organized by the researcher into main topics or categories of similar interest. The courses given in each semester were categorized into main topics as represented in the chart below figure 38. The contribution percentage for each course along the 5 years of study was calculated as well.

Unviersity	USEK	Credits	City University	Credits	AUB	Credits	LAU	Credits	NDU	Credits	BAU	Credits	Al Azm	Credits	Phoenicia	Credits	LU / ALBA
First Year																	
Fall Semester		13		15		18		16		15		18		19		15	
Design Studio	Basic Design I	2	Basic Design	3	Basic Design	6	Design Studio I-A/B	6	Principles of Architectural Design	3	Architectural Design Fundamentals: Visual Studies	6	Design Methods	3	Design Studio I (Foundation Level part I - Basic Design)	6	Architecture studio 1
Engineering and construction	Technical Drawing	2			Introduction to Engineering and Architecture	3	Shop Techniques	1	Technical Drawing I	3	Building Construction I	2	Technical Drawing	3			Mathmetics
Theory	Vernacular Architecture	4	Perception and Communication I	3					Descriptive Geometry	3					Basic and Introductory Architectural Theory - Part I	3	Theory of architecture1
History			History of Arts	3	History of Art and Architecture I	3					History of Architecture I	2					History of architecture: Pre-history+A67
Hand Skills	2-3D Representation Skills	2	Freehand Drawing	3	Drawing I	3	Drawing for Foundation	3	Drawing I	3	Architectural Sketching	2	Freehand Drawing	3	Architectural Artistic Drawings I - Basic Design	3	Drawing, Sketches and Colours - 1
Digital Drawing							Digital Media	3			CAD Drawing	2					
Materials													Statics & Mechanics of Materials	3			
	General Studies	3	FAD Major Elective	3									Introduction to Materials	3	English I (GE)	3	
General Education Courses											General English	2	English Communication Skills I	3			French language
					Academic English	3	LAC	3	LAC	3	Program Elective Course	2	Orientation to the Major	1			
Spring Semester		11		15		15		15		18		18		18		18	
Design Studio	Basic Design II	2	Space-Form Design	4	Architecture Design I	6	Design Studio II	6	Architectural Sketching and Rendering	3	Architectural Design Fundamentals: Physical Studies	5	Basic Design in Architecture	3	Design Studio II (Foundation Level part II)	6	Architecture studio 2
Engineering and construction	Strength of Materials I	2							Technical Drawing II	3	Building Construction II	3	Design in Construction I	3	Architectural Technical Drawings & Representation II	3	Elements of construction
Theory	Architecture Analysis and Perception	4			History of Art and Architecture II	3	Design Culture	3	Methodology of Architectural Design	3	Theory of Architecture I	2			Basic and Introductory Architectural Theory - Part II	3	Theory of architecture 2
History					Statics and Mechanics of Solids	3			History of Architecture I	3							History of architecture in middle age
Hand Skills																3	Drawing, Sketches and Colours - 1
Digital Skills					Drawing II	3					Computer Graphics	2					
Building Technology									Building Technology I	3							
Other Discipline			Portfolio Presentation	2									Structural Mechanics and Analysis	4			
Sustainability																	
Photography			Photography I	3			Photography for Foundation	3									
	General Studies	3	Advanced Academic English	3							Program Elective Course	2	Research Methods	1	English II (GE)	3	2D Plastic Practices
General Education Courses			FAD Major Elective	3			LAC	3	LAC	3	Arabic Language	2	Architectural Communication	4			
											Academic Writing	2	English Communication Skills II	3			
Summer Semester		3		0		9		12		6		0		6		9	
	General Studies	3					Art Elective	3					Principles of Sustainable Architectural Design	3			
General Education Courses							LAC	3	LAC	6			Arabic	3	Introdcution to Computing for Arts (GE)	3	
Skills							Sketching	3							Architecture Elective (Media & Graphics)	3	
							Technical Graphics	3									
Other Discipline					Surveying Regional Architecture 2D-3D	9									World Civilization I (GE)	3	
Internship													Internship I - Material Workshops & Construction Site Visits	0			
Second Year																	
Fall Semester		24		25		18		16		15		18		18		18	
Design Studio	Architecture Design Studio I	6	Architecture Design I	4	Architecture Design II	6	Design Studio III	6	Architectural Design I	6	Architectural Design I	5	Architectural Design I	5	Design Studio III	6	Architecture studio 3
									Applied Architecture Design I	3							
Engineering and construction	Building Technologies	2	Building Construction I	3	Structural Systems	3	Technical Graphics II	3	Statics of Architecture	3	Building Construction III	3	Design in Construction II	3	Building Construction I	3	
	Structural Design	2			Building Construction I	3											
Theory							Thoery I	2			Theory of Colors	2					Urban sociology
											Theory of Structures for Architects	2					
History	History and Culture of Architecture I	3	History of Architecture I	3	History of Art and Architecture III	3	History of Architecture I	3	History of Architecture II	3	History of Architecture II	2	World History of Architecture I	4	History of Architecture I	3	History of architecture in the period of Renaissance: European and Ottoman
																	History of contemporary plastic art
Hand Skills																	Drawing, Sketches and Colours - 2
Digital Drawing	CAD	2	Computer Aided Design I	3			Computer Graphics I	2					Computer Aided Design I	3	Architecture Elective (Computer Graphics)	3	
Materials	Strength of Materials I	3	Statics	3									Concrete & Steel Structures	3	Structural Systems I / Building & Materials Mechanics - Statics	3	Statics
Photography																	Photography
	2 General Studies	6	2 Univeristy Requirement	6							Human Rights	1					

Unviersity	USEK	Credits	City University	Credits	AUB	Credits	LAU	Credits	NDU	Credits	BAU	Credits	Al Azm	Credits	Phoenicia	Credits	LU / ALBA
General Education Courses			FAD Major Elective	3							Program Elective Course	2					
					1 General Education Requirement	3					University Requirement	1					Architectural research methodology
Spring Semester		15		22		15		15		18		18		18		18	
Design Studio	Architecture Design Studio II	6	Architecture Design II	4	Architecture Design III	6	Design Studio IV	6	Architectural Design II	6	Architectural Desgin II	5	Architectural Design II	5	Design Studio IV	6	Architecture studio 4
Engineering and construction	Reinforced Concrete I	3	Structural Analysis	3	Building Construction II	3	Technical Graphics III	3	Building Technology II	3	Building Construction IV	3	Design for Execution	3	Building Construction II	3	
Theory			History of Architecture II	3			Theory II	2			Theory of Architecture II	2					
											Indoor Environmental Controls	2					
History					Contemporary Architecture	3	History of Architecture II	2	History of Architecture III	3			World History of Architecture II	4	History of Architecture II	3	History of architecture: Modern Architecture
																	Urban composition, historical and contemporary readings
Hand Skills																	3D Plastic Practices
Digital Drawing			Computer Aided Design II	3			Computer Graphics II	2					Computer Aided Design II	3			AUTOCAD Computer Assisted Drawing – 2D
Materials	Strength of Materials II	3							Strength of Materials	3	Concrete and Steel Structures	2	Building Structures & Seismic Design	3	Structural Systems II	3	Material resistance
																	Technical equipment – Electricity + Lighting
General Education Courses	General Studies	3	2 Univeristy Requirement	6							Program Elective Course	2			Architecture Elective (Advanced Computer Graphics)	3	
			FAD Major Elective	3	1 General Education Requirement	3			LAC	3	University Requirement	2					
Summer Semester		6		3		9		10		6		0		4		6	
General Education Courses	2 General Studies	6	1 Univeristy Requirement	3	3 General Education Requirements	9	Building Systems I	3	LAC	3			E-Portfolio	1	Regional Architectural Survey & Documentation	3	
							LAC	6	Free Elective	3			Community Engagement Project	3	Architecture Elective (3D Max)	3	
Internship							Professional Elective	1					Internship II - Material Workshops & Construction Site Visits	0			
Third Year																	
Fall Semester		15		20		15		15		18		18		18		18	
Design Studio	Architecture Schematic I	2	Architecture Design III	4	Architecture Design IV	6	Design Studio V	6	Architectural Design III	6	Architectural Design III	5	Architectural Design III	6	Design Studio V	6	Architecture and Interior Design Studio 5
									Applied Architecture Design II	3							
Engineering and construction	Reinforced Concrete II	3	Advanced Building Construction	3			Building Technology I	2	Construction Detailing Studio I	3	Execution Design I	3					
							Building Systems II	3									
Theory	History and Theory of Architecture II	3									City and Town Planning	2	Contemporary Architectural Theory	3			Landscape architecture 1
History			Contemporary Architecture	3	History of Art and Architecture III	3			History of Architecture IV	3	History of Architecture III	2			History of Architecture III	3	Architectural heritage
Hand Skills																	
Digital Drawing					Digital Tools	3							Computer Modelling	3			
Materials	Sanitary and Mechanical Equipment	2	Wood and Metal Shop	2	Environment I - Climate Responsive	3			Structural Analysis	3	HVAC and Sanitation for Architects	2	Mechanical Design of Buildings	3	Building and Environmental Systems I / Climate & Electro-Mechanical Engineering	3	Technical equipment (air conditioning + sanitary)
			Surveying	2													Basic building materials and processes
			Building Services 1	3													Material resistance 2
Law													Building Codes and Laws	3			
General Education Courses	General Studies	3	FAD Major Elective	3			LAC	4			University Requirement	2			Architecture Elective (Digital Tools)	3	
	Student Chosen Optional	2									Program Elective Course	2			Workplace Etiquette (Mandatory Workshop)	3	
Internship																	Professional internship 1
Spring Semester		17		16		15		15		18		18		15		18	
Design Studio	Design Studio II	6	Architecture Design IV	4	Vertical Studio I	6	Design Studio VI	6	Architectural Design IV	6	Architectural Design IV	5	Architectural Design IV	6	Design Studio IV	6	Architecture studio 6
	Architecture Schematic II	2															
Engineering and construction	Reinforced Concrete II	3	Architecture Execution Drawings I	3	Environment II - Building Systems	3	Building Technology II	2			Execution Design II	3	Electrical Design of Buildings	3	History of Architecture IV	3	Execution drawings 1
			Structural Design	3			Building Systems III	3	Construction Detailing Studio II	3							
Theory					Urbanism	3					Theory of Architecture III	2					
History					History of Art and Architecture III	3											
Hand Skills																	
Digital Drawing													Computer Modeling & BIM	3			
Law																	Laws of town planning and buildings
Materials	Electrical Lighting	2	Building Services 2	3					Reinforced Concrete Design	3	Interior Design	2			Building and Environmental Systems II / Climate & Electro-Mechanical Engineering	3	Reinforced cocnrete 1
									Bio-climatic Architecture	3	Environmental Design	2					Soil mechanics
General Education Courses	General Studies	2	FAD Major Elective	3			Professional Elective	3	LAC	3	University Requirement	2			Communication Elective (GE)	3	
	Student Chosen Optional	2					LAC	1			Program Elective Course	2	GE	3	Architecture Elective	3	
Summer Semester		4		1		0		11		9		0		0		0	
General Education Courses	General Studies	2					Construction Documents	4	LAC	3							
	Student Chosen Optional	2							LAC	3							
							LAC	7	Free Elective	3							

Unviersity	USEK	Credits	City University	Credits	AUB	Credits	LAU	Credits	NDU	Credits	BAU	Credits	Al Azm	Credits	Phoenicia	Credits	LU / ALBA
Internship	Professional Practice	0	Architecture Internship 1	1	Training in Construction Drawings	0							Internship III – Local Design Office/ Execution Drawings	0	Professional Training I	0	
Fourth Year																	
Fall Semester		14		13		15		16		15		18		15		15	
Design Studio	Design Studio V	6	Architecture Design V	4	Architecture Design V	6	Design Workshop I	1	Architectural Design V	6	Architectural Design V	5	Architectural Design V	6	Design Studio VII	6	Archiecture studio 7
							Design Studio VII	5									
Engineering and construction			Architecture Execution Drawings II	3			Building Technology III	2			Execution Design III	3					Construction finishing processes and materials
Theory	Urbanism I	3	Urbanism	3			Urban Planning I	3	Social Architecture	3	Urban Design	2	Urban & City Planning	3	Globalization & World Cultures (GE)	3	
									Urbanism I	3							Vernacular and traditional architecture
History							History and Theory Elective	2							Introduction to History & Theory of Urban Design and Landscape Design	3	Contemporary Urban Planning
Sustainability							Environmental Systems I	3									Sustainable architecture
Management											Project Management	2					
Law	Standards, Codes and Building Laws	2							Building Rules and Regulations	3					Professional Practice I	3	
Materials											Soil Mechanics & Foundation & Material Properties & Testing	2					Reinforced cocnrete 2
	Required Optional	3	General Elective	3	2 Field or Free Electives	6					Program Elective Course	2	GE	3			
General Education Courses					1 General Education Requirement	3					Program Elective Course	2	Major Elective 1	3			
Spring Semester		15		13		15		16		15		18		15		18	
Design Studio	Final Design Studio	6	Architecture Design VI	4	Vertical Studio II	6	Design Workshop II	1	Architectural Design VI	6	Architectural Design VI	5	Architectural Design VI	6	Design Studio VII	6	Architecture studio 8
							Design Studio VIII	5			Research and Programming	3			Architectural Programming	3	
Engineering and construction							Building Technology IV	2			Execution Design IV	2					Execution drawings 2
Theory	Urbanism II	3	Landscape	3					Urbanism II	3							Urban project
History																	Restoration of buildings
Sustainability			Energy Efficient Design	3			Environmental Systems II	3									
Law	Construction Document	3													Professional Practice II	3	
Management									Project Planning and Management	3	Specifications and Quantities	2					Economics and project management
Materials					Professional Practice	3	Building Systems IV	3	Surveying and Field Surveying	3	Surveying for Architects	2					Spatial structures and contemporary techniques/1
	Required Optional	3	General Elective	3	2 Field or Free Electives	6	Seminar	2			Program Elective Course	2	Major Elective 2	3	World Civilization II (GE)	3	
											Program Elective Course	2	Major Elective 3	3	Architecture Elective	3	
General Education Courses													Major Elective 4	3			
Summer Semester		0		1		0		7		5		0		0		0	
General Education Courses							Professional Elective	3	Senior Study	2							
							LAC	3	Major Elective II	2							
Internship			Architecture Internship 2	1	Professional Training	1b	Internship	1	Internship	1			Internship IV – International Design Office	0	Professional Training II	0	
Fifth Year																	
Fall Semester		15		9		15		9		7		14		12		12	
Design Studio	Master Architetcure Design Studio I	6	Final Project Design I	5	Design Thesis I	6	Design Studio IX	5	Senior Studio I	4	Architectural Design VII	5	Final Year Project I	6	Design Studio IX - Graduation Project part I (Theory & Thesis)	6	Architecture studio 9
							Final Project Research	1			Graduation Project Programming	3					Graduation project, research and preliminary period
Theory	Architecture Resarch Methodology	3									Graduation Dissertation	2					Spatial structures and contemporary techniques 2
	Graduation Project Thesis	3															
Law							Building Codes & Laws	1			Building Regulations and Professional Practice	2					
Management			Construction Management	3													
	Student Chosen Optional	3			3 Field or Free Electives	9	Professional Elective	2	Major Elective I	3	Program Elective Course	2	Major Elective 5	3	Architecture Elective	3	
General Education Courses													Major Elective 6	3	Social Science Elective (GE)	3	Seminar
Internship			Architecture Internship 3	1							Architecture Internship	0					Professional internship 2
Spring Semester		10		12		15		10		7		12		12		12	
Design Studio	Master Architecture Design Studio II	6	Final Project Design II	6	Design Thesis II	6	Design Studio X	5	Senior Studio I	4	Graduation Project	8	Final Year Project II	6	Design Studio X - Graduation Project part II (Design)	6	Graduation project
Theory	Theory and Critic of Contemporary Architecture	3	Business Practice for Building Design	3							ARCHITECTURAL CRITICISM	2					
Law			Building and Urban Regulations	3													Professional ethics
Materials											Design and Building Economics	2					
General Education Requirements					3 Field or Free Electives	9	Professional Elective	2	Major Elective II	3			Major Elective 7	3	Basic Science Elective (GE)	3	
Internship	Profesisonal Internship	1					LAC	3					GE	3	Arabic (GE)	3	
		162		165		174		183		172		170		170		177	

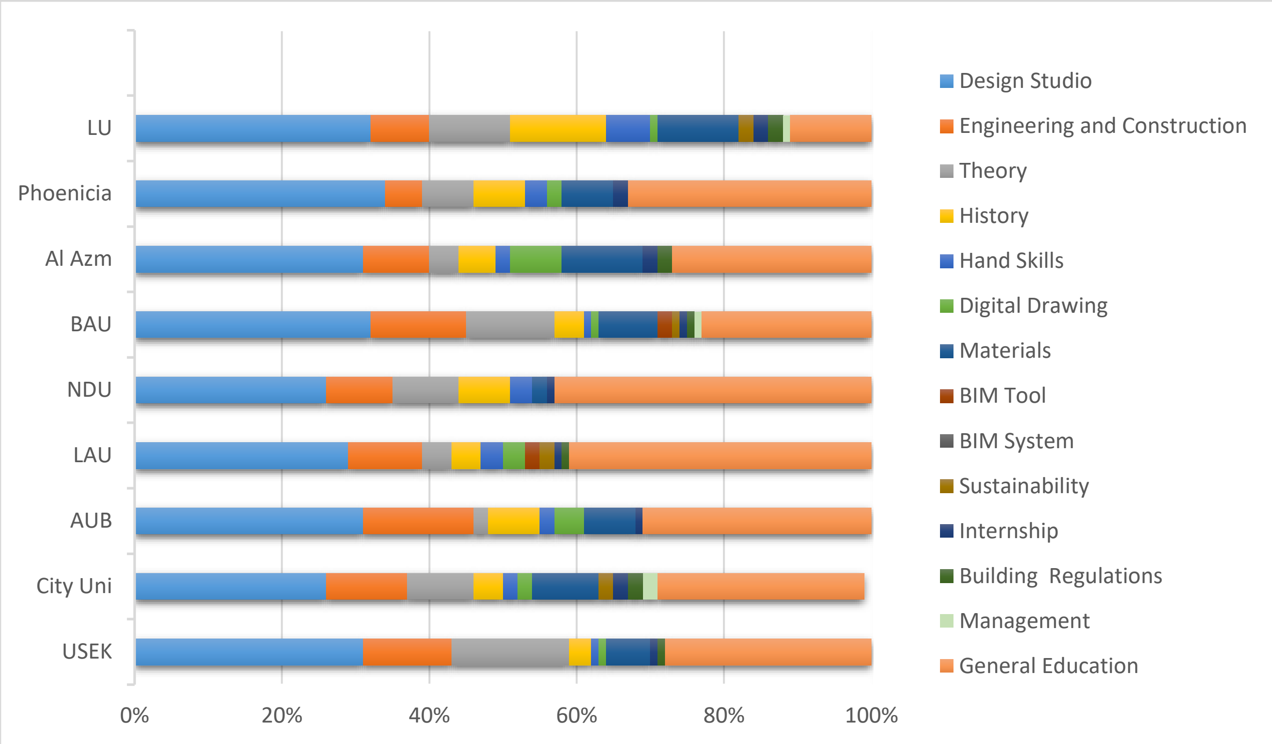


Figure 3-9 Distribution of the architectural undergraduate program between the accredited Lebanese Universities

- LU: Lebanese University
- BAU: Beirut Arab University
- NDU: Notre Dame University
- LAU: Lebanese American University
- AUB: American University of Beirut
- USEK: Holy Spirit University of Kaslik

The subjects which formulate the curriculum were assessed across the undergraduate architectural program of the accredited Lebanese universities, which occupy a time period of 5 years. These subjects include the assessment of BIM implementation as a tool and as a whole system in each of these universities.

The subjects were filtered and categorized into 14 main topics: Design Studio, Engineering and Construction, Theory, History, Hand Skills, Digital Drawing, Materials, BIM Tool, BIM System, Sustainability, Internship, Building Regulations, Management, and General Education. The above figure clearly highlights that the bulk concentration in all universities relies in the design studio-related courses with an average of 30% of pre-requisite design studio along the 10 semesters. The second highest concentration marks in the courses under the general education topic with an average marking of 27%. The contribution of this percentage to the whole architectural curriculum is considered high since general education courses are secondary and not primary. This suggests reducing the share of general education mandatory and elective courses and the substitution of some of these courses with BIM stand-alone courses. Next marks the engineering and construction courses with an average of 10%. This category of courses focuses on the technical aspect of construction and is therefore expected to come in second place after the aesthetics of architectural design rather than the general education courses. It is suggested that the contribution of technical construction courses in the architectural curriculum to be increased and involve BIM application. An average of 8% is recorded for theoretical courses which is also expected to increase slightly upon the introduction of BIM in its basic theoretical form. An average of 7% is recorded for materials courses and 6% for the average of historical courses. Manual hand skills and digital tools marked respectively an average of 3% and 2%. The share of digital tools needs to be improved, whereas teaching BIM tools should be mandatory. It is worth noting here that some universities favored digital tools rather than manual tools and vice versa. For instance, the LU focuses on developing the manual skills of the students with 6% of the hand skills courses distribution in favor to 1% for the digital courses. Meanwhile, Al Azm University implements more technological programs in its course education with 7% for the digital courses and 2% for the hand drawing courses. The lowest courses category was recorded with an average of 1% for the topics of sustainability, building codes, management, and internship courses where some of these courses do not form a part of the architectural program in some universities. For instance, 4 out of 9 universities have included sustainability courses within their curriculum, 6 out of 8 universities have delivered in their courses structure building regulations content and 3 out of 9 universities have considered management courses in their curriculum structure at senior levels. Moreover, all 9 universities have included architecture internship modules in their curriculum for at least once in their program structure. These percentages may need to be enhanced upon the implementation of BIM, especially that BIM contributes mainly within the issues of management, sustainability, and practice.

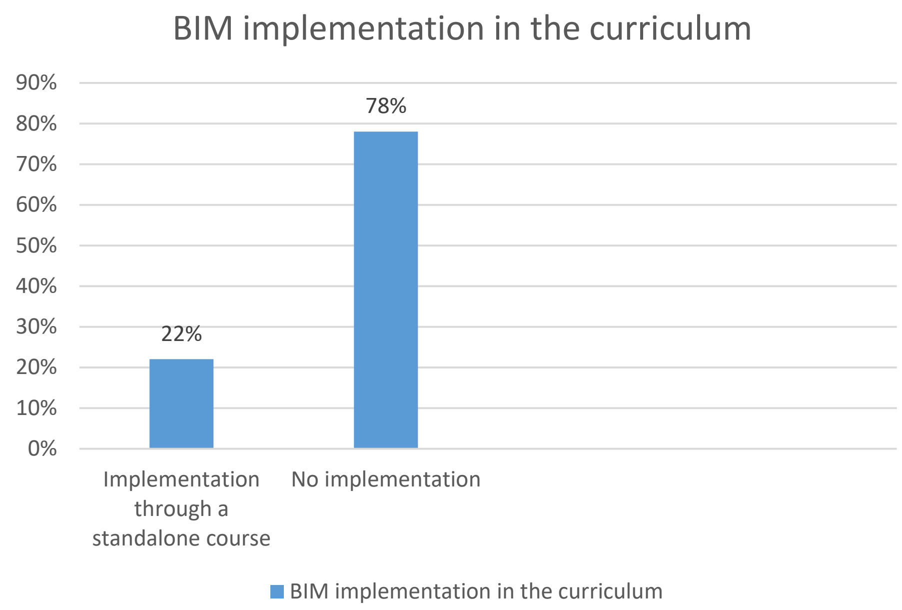


Figure 3-10 Diagram showing implementation of BIM in the Lebanese architectural curriculum

The core focus of this research study is the implementation of BIM across the Lebanese universities which can be assessed from two scopes: BIM as a tool in the form of Revit and BIM as a whole system. Only 2 universities out of 9 have introduced BIM in the form of Revit tool through a single course program in LAU and BAU universities, which marks 2% for each. Unfortunately, none of the Lebanese universities have implemented BIM as a whole system or through a multi-disciplinary system.

When comparing BIM awareness with respect to its implementation, the recorded results of 18% of the students being aware of BIM, regardless of their understanding of it as a tool or system, and with more than half of academic staff being aware of BIM, the implementation results within the curriculum are alerting. This implies that students and tutors have the awareness of the external environment through practice, websites, colleagues, or research, and therefore they reflect the willingness to know more about BIM. The problem here relies within the educational institution itself in not taking the effort at all to implement BIM or not having the correct guidelines to do so.

Various reasons might stand behind this low contribution of institutions to implement BIM. From the observation of the curriculum structure, these reasons are: the stacked number of credit hours in the architectural program, where introducing more courses might not be an option for the majority of the universities. Yet, with general education courses taking the second largest share of the curriculum, ranging between 11% and 43%, universities need to compromise from these courses in favor of BIM introduction within the curriculum. Although more than half of the academic staff has BIM awareness, not everyone has the required understanding of it to teach it to students. It is necessary to train the academic staff fully in the first place and ensure that they have gained the necessary BIM knowledge. Third, the implementation of BIM should take place gradually through standalone courses as a first step in the first year of the architectural program and then as a multi-disciplinary system across the following years. Two universities, as highlighted earlier, have already taken this initiative but did not progress to the full implementation of BIM.

The weaknesses that exist in the existing curriculum, that are preventing the partial or full implementation of BIM, shall be explored and assessed further in the upcoming section which deals with the semi-structured interviews with the tutors. Upon the results, a defined framework that structures the implementation of BIM within the architectural curriculum shall be developed, taking into consideration all the existing gaps, barriers, and opportunities.

3.1.2. Learning Objectives in Curriculums

The learning outcomes listed in the handbook of each faculty were further explored in order to align the new BIM-related learning outcomes in the developed framework with the current set ones. Generally, the structure of the learning outcomes is similar among all the 9 universities and can be categorized as follows:

1. Design: Reflects the full understanding and knowledge of architectural and engineering concepts and practices through the application of integrated design thinking at different levels of complexity and foster creative thinking and problem solving skills.
2. Technical: Utilizes the principles of structural, material, and service systems of different disciplines, and integrates them into a comprehensive building design that gives value to their design.
3. History and Theory: Support students with the knowledge in history, material and cultural precedents in the fields of architecture, art, and urbanism. Provide students with the adequate understanding of traditional, modern, and contemporary theories and philosophies of architecture by famous architects.
4. Representation Techniques: Develop manual and digital drawing skills that enable students to represent their ideas in different visual methods: sketching, 2D and 3D models, physical-model making and fabrication to develop and communicate design ideas.
5. Professional Practice: Demonstrate an understanding and knowledge in the professional and ethical responsibilities, standards, building regulations, and law. Demonstrate the ability to communicate and work with a team from different disciplines and roles in the construction industry.
6. General: Demonstrate the understanding of general skills and critical implementation of instructions from local or international perspectives and reflect the confidence and positively respond to design criticism as an integral part of the creative process.

The stated common learning objectives do not include in their focus any BIM specific outcomes. The modification of these standards shall set new BIM-expected outcomes or an update on the existing objectives to reflect BIM understanding, BIM knowledge, and BIM skills. The approach to introduce BIM in the curriculum and the tools to adequately assess BIM outcomes are discussed in detail in upcoming chapter (5).

Chapter 4 **RESEARCH METHODOLOGY**

The following chapter deals with the adopted research methodology in response to achieving the aims and objectives of this study. First, the chapter starts with layering the research methodology used in this study. Next, the philosophy behind the research and the adopted strategy are explained. Afterwards, the process used in collecting the data and analysis is clarified. Finally, the ethical considerations taken into account are outlined.

4.1. Introduction

This research emerges from an existing problem in the architectural education and profession where BIM has shown gaps in implementation. BIM is a powerful tool that elevates the level of students on one hand and the level of projects delivery on another. This research developed a framework that supports the adoption of BIM in undergraduate architecture programs and curriculums. Based on the defined terms of Hussey and Hussey (1997), the research outcomes of all analysis from literature review and semi-structured interviews resulted in the framework elaboration, which supports the integration of BIM within the undergraduate architectural programs that serve in turn the learning objectives. The framework gained validation through the examination of educational and professional opinion.

The developments that encounter BIM topics revolve around the process of innovative technology and information management, which are affected to a level by the demand of change by the market. When researching BIM as a technological development tool or as a new software for designers, a new methodology is needed in order to evaluate the potential of this tool and its changing effect on the environment upon its introduction (Kehily and Underwood, 2015).

The goal of the methodology was to plan a structural approach that answers a series research questions through multiple methods. These questions focus on the existing architectural demands of the market and the upcoming expected ones. It moreover deals with the challenges and the current level of BIM understanding. The methodology addressed questions related to the current implementation methods and whether they achieve a co-relation between the learning objectives and the industry demands. The aim of the research and the initial point of the methodology is to reach an effective BIM implementation framework in the architectural curriculum to achieve the optimum level of benefits.

The process of research involves searching for data through different methodological enquiries, finding solutions to existing problems, and adding to the value of knowledge through significant findings (Herbert, 1990).

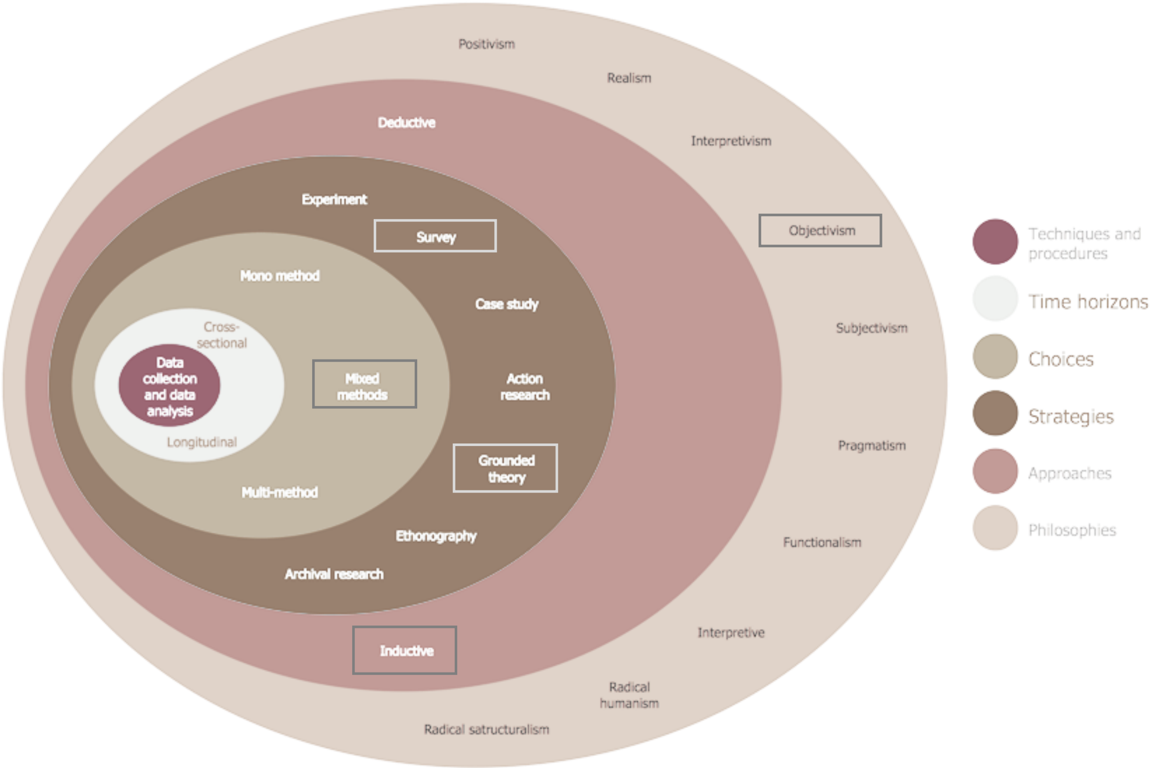


Figure 4-1 Research Onion (Source: adapted from Saunders et al, 2006).

The research process is more likely described as the concept of the research onion according to Saunders et al, 2007. Similar to the layers of the onion, the research approach is basically composed of several layers that formulate the whole research process. The first layer deals with the research philosophy, while the second one considers the research approach and the third layer examines the research strategy. The fourth layer represents the time frame and the fifth one raises questions related to data collection methods. All of these phases act as the research process that necessitates the contribution of one another for a complete one.

The layers of the research onion are:

a- Layer 1: Research Philosophy

The research philosophy relies on the people's views and assumptions (Coates, 2013), and is defined as "the critical examination of the grounds for fundamental beliefs and an analysis of the basic concepts employed in the expression of such beliefs" (Encyclopaedia Britannica , 2002). This research has a socio-technological aspect and i is following the Design Science Research approach, which will study the needs of the academia and the relevant theories of this implementation and will transform them to solve the problem of implementation using the created artifact.

b- Layer 2: Research Approach

The second layer in the research onion is the research approach, which is divided according to researchers into: Deduction, Induction, and Abduction. The selection of the research approach impacts the relationship between the research and the theory (Saunders et al., 2012). The difference between the three research approaches relies in the method. In the deduction approach, the researcher is influenced by the question generation from theory, whereas in the induction approach the theory is built based on a case and in the abduction approach the research is taken from theory to findings and then back to the theory (Saunders et al., 2012).

c- Layer 3: Research Strategy

The research strategy is closely defined as a road map which leads the way to achieving the research goals and thus answer research questions (Saunders et al., 2009).

The research strategy for this research is following the design science research approach, which consists of semi-structured interviews focus groups and discussion. The interviews were split into three categories, the first is to answer the missing parts from the literature review, the second is to answer the questions about the appropriate method and the third is to validate the developed framework.

d- Layer 4: Research Choice

The next layer of the research onion is the research choice. The research can typically use a single data collection method and a corresponding data analysis procedure (mono method) or it can combine multiple techniques in processes, which is known as a mixed method approach. In this type of approach, both the quantitative and the qualitative data collection methods and analysis procedure are used (Saunders et al., 2009).

The data of these research were analyzed differently depending on the interviews. Some of the responses were direct to the point and objectives and other interviews where more subjective relying on opinions and experiences.

e- Layer 5: Time Horizon

For the next research onion layer, the time horizon, a cross-sectional timing was utilized with the conducted research. A research may be constrained with the factor of time or it can be considered as a "snap shot" research, which is known as a cross-sectional study or it may be within a longer time frame or a series of diaries or snap shots (Saunders et al., 2009).

f- Layer 6: Techniques and Procedures and Research Instruments

The final layer in the research onion relates to taken techniques and procedures. The inner most layer of the research onion is composed of the processes of data collection and data analysis methods as represented in Fig 13. An important aspect for the researcher is to ensure that there is no bias in the data collection process. When interpreting the data, it is analyzed against the theoretical framework.

4.2. Research Philosophy

The research philosophy is related to the understanding of the researcher to his study in relation to the research background and the related knowledge developed (Saunders et al., 2012). The research philosophy aims in the first place to aid the research in building the core of theories based on the research objectives and questions. The importance of the research philosophy is conveyed through three aspects. Firstly, it helps the researcher in explaining the research design, secondly it detects the research type that is best suitable and thirdly it identifies and develops new designs that may be the result of past experiences (Easterby-Smith et al., 2012).

The final outcome of this research was a structured framework that guides the implementation of BIM technology within the architectural curriculum, therefore the subject of this research was technological and BIM structured. The capability of BIM is its potential in developing the way stakeholders view the building process since the start of conceptual design till the end of the construction and into the building's operational phase (Dzambazova et al., 2009).

The developments that encounter BIM revolve around the process of innovative technology and information management, which are affected to a level by the demand of change by the market. When researching BIM as a technological development tool or as a new software for designers, a methodology is needed in order to evaluate the potential of this tool and its impact on the built environment upon its introduction (Kehily et al 2015).

The relevance of academic research is outlined by Van Aken (2015). Aken supports the usage of "mode 2 research products" stated by Gibbons et al. which offers relevant academic research for practice. The difference between both modes, outlined by Kelemen & Bansal 2002 and Voordijk 2009, is that the first mode follows a traditional research practice in universities which means that problems are identified by the intellectual interests of academics. Meanwhile, mode 2 of the research focuses on the practical applicability of knowledge. This knowledge is drawn through emerging issues in the industry, research center, consultancies, governmental agencies, and companies. According to Voordijk 2009, mode 2 is more concerned with knowledge as it works in practice rather than the discipline base. Also, Aram et al 2016 discusses how mode 2 knowledge production is the result of the union of specialized disciplines who are working in different institutions, but in one context of defined problem.

In this research, the second adopted mode of knowledge was effective when exploring solutions for the built environment-related issues. It furthermore helped in the assessment of applied practice and during the validation process of the new knowledge.

The traditional academic research methods are limited to the description of existing methods rather than the formation of new non-traditional ones (Aken, 2005). In this BIM research, the Design Science Research approach was needed for its utilization in the validation of the technological change resulting from the transitional process to BIM workflow. This research presents an alternative methodology to traditional research strategies which allows BIM researchers to develop and evaluate adequate solutions to be implemented (Kehily and Underwood, 2015).

The ways of knowing various philosophy approaches are mainly categorized as: positivism, interpretivism, realism, critical theory, hermeneutics, and phenomenology. Commonly, the research strategy and methods are selected based on the stances of research philosophy (Saunders et al., 2009). This did not center the research paradigm, which is focused on practical problem solving known as Design Science Research (DSR). The philosophical approach of this research study is based on the DSR philosophy which is established on the characteristic of BIM.

	Research Perspective		
Basic Belief	**Positivist**	**Interpretive**	**Design science research**
Ontology	A knowable predictable reality	Multiple realities which are constructed socially	Multiple, contextually situated alternative world stress, socio technologically enabled
Epistemology	Objective, dispatched	Subjective, values and knowledge	Knowing through making: objectively

	observation of the truth	come from the researcher participant interaction	constrained construction within a context
Methodology	Observation: quantitative & statistical	Participation: qualitative	Developmental: measure artefact impacts on the composite system
Axiology	Truth: realistic and universal	Understanding: situated and description	Control: creation progress and understanding

Table 4-1 Philosophical Assumptions of Three Research Perspectives (Vaishnavi et al 2008)

Table 3-1 summarizes the philosophical assumptions of the top three "ways of knowing", which reviews findings of more than 40 years of design science research experience (Gregg et al., 2001). While the positivist perspective tends to be more objective, realistic, and quantitative the interpretive perspective is, on the contrary, more subjective and understanding to socially-constructed realities and qualitative. The third perspective, concerned with the Design Science Research (DSR), relies on knowing through making and developing artefacts. DSR is rooted in the architectural and engineering disciplines. DSR aims to serve the human purposes through new creations and utilities for the stakeholders (March and Smith, 1995). While natural and social sciences try to understand the reality and do not aim to the direct applicability of their findings. The scientist who adopts the DSR approach builds artifacts that act as a relevance and seeks to define a solution to the identified problem (Hevner et al., 2004). For this purpose, DSR was seen as alternative research approach for this research, which practically offers solutions to relevant problems.

The primary focus of the artifact lies within the problem itself and is not completed until it satisfies the requirements of all stakeholders and solves the relevant problem. Yet, it is necessary to keep in mind that an artifact might not actually work depending on how it was created. (Hevner et al., 2004). In order to better understand how an artifact was created, it is necessary to understand the underlying kernel theories of it. Kernel's theories are defined by the evaluation and modification of the natural and social science theories.

Moreover, they are a result of the researcher's experience and creativity (Hevner et al., 2004; Markus et al., 2002; Walls et al., 1992). Therefore, DSR acts both: as development of new solutions of artifacts to existing but unsolved problems and/or matching solutions to new and unresolved problems (Holmström et al., 2009).

The various readings about research methodology in reference books realize that there is no ideal way of undertaking a specific research project. The most crucial issue is that the researcher should be able to make choices and know how they could possibly impact on what can be found at a later stage. This means that the researcher can make an informed choice regarding strategies, approaches, and methods that are most fit for the research project.

This research study adopts the DSR philosophical approach which aims to discover and identify the problems and opportunities related to the implementation of BIM in the architectural curriculum. The intent was to create new concepts which addressed the problems and established theoretical explanations.

4.2.1. Research Approach

BIM, as a recent technology, can't be used alone as a theory without being implemented within the suitable environment. This intension of this research is an outcome that provides guidelines for the implementation of this technology and this is done by transferring the theories and observations into a practical framework. This process can take two forms of research: empirical research and design science research. The aim of empirical research is to describe, explain, and predict the world. A real example of empirical research is represented by the kingdom of animals and plants, where each is classified into species and families, which is described by the Linnaean taxonomy. The law of Newton was able to explain natural movements, such as the movement of planets, the routes of missiles, and the tides reasons. Also, meteorology predicts storms, rain, and weather phenomena. The goal here of empirical research relies in the ability to faithfully describe and explain the real world as it exists regardless of the interests and biases of human. On another level, the process of design research is not only limited to the description, explanation, and prediction, but it additionally extends to change the world and create improvements. This is achieved through developing artefacts that can help people in fulfilling their goals in overcoming problems and creating solutions. This endeavor not only creates novel artifacts but data related to their use and environment. (Johannenson & Perjons, 2012)

This research took the transitional form which concentrates on translating the informational theories from education and basic research into new knowledge ready to be implemented in the educational curriculum. It simply made use of the existing theories to create solutions that could be implemented on the ground for solid change and improvement. The major contribution of this research is "to develop a framework for the implementation of BIM within the architectural curriculum in Lebanon".

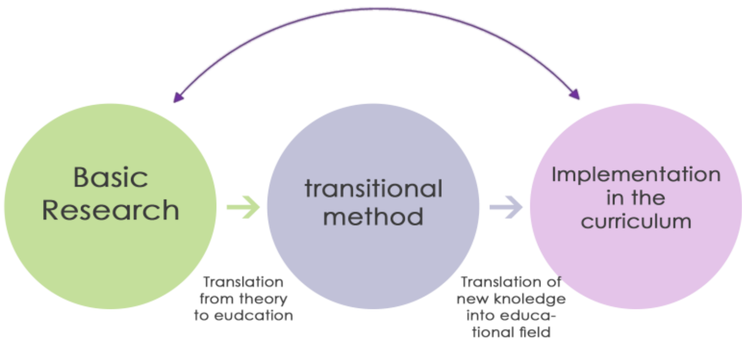


Figure 4-2 Transitional research Diagram (source: Grimshaw et al, 2012.)

This research illustrates the basic concepts of BIM and architectural education. It connects the two together through exploring the effect of the implementation of BIM on architectural education and assessing the gaps that were detected. The process of analysis identifies all existing problems in order to transfer to the practical framework that shall be implemented in the architectural educational curriculum in an effective manner.

4.3. Research Strategy

Design science research doesn't only deal with artifacts but also answers questions related to them. The use of research methods as stated previously is important in order to ensure transparency and reliability in the formulated answers. When the project takes the direction of design science research, no research method can be excluded. Hence, the researcher has the opportunity to use any research strategy suitable for the study depending on the characteristics of the project. When it comes to large-scale DSR projects, it is common to use multiple research strategies as a response to different DSR events (Johanesson, 2012). Two strategies were adopted in this research: semi-structured interviews and group discussion.

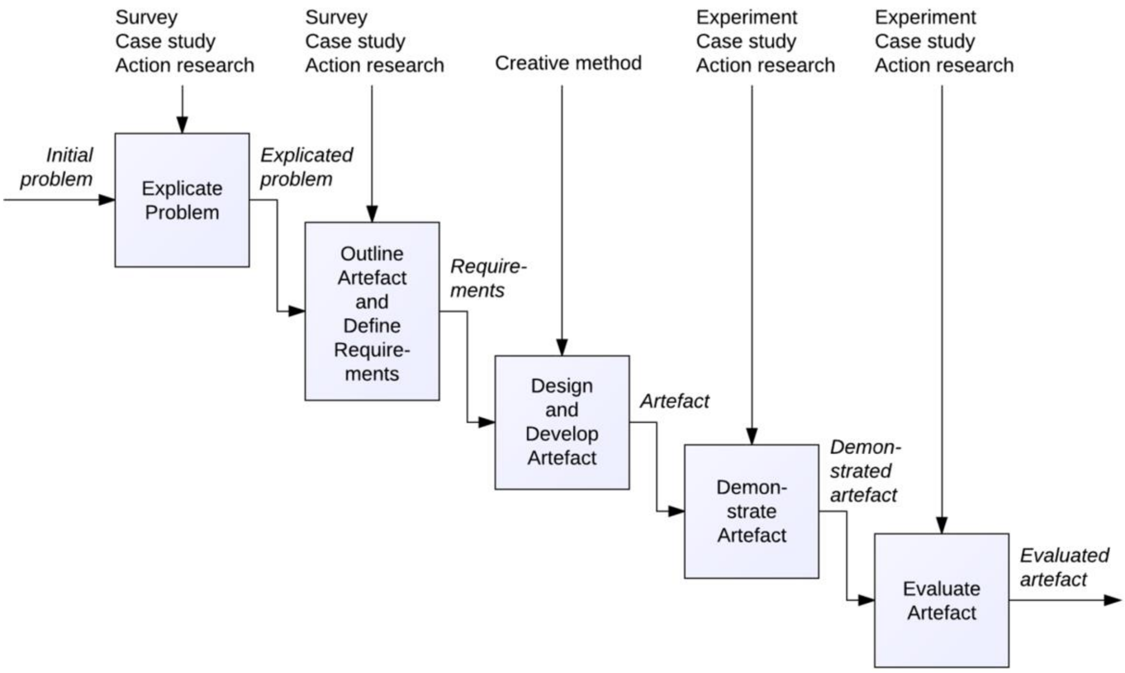


Figure 4-3 Suggested use of research strategies in the DSR method (Johanesson 2012)

4.3.1. Semi-Structured Interviews

The role of the interview is to give the researcher the opportunity to engage in a dialogue with the participants in order to demonstrate the problem in an interactive way of thinking, where the researcher can track the respondent's answers by asking follow-up questions. The variety of perspectives and interests given through the interview ensures the transparency of the research process in obtaining answers and solutions for the existing problems (Johannesson, 2012).

To perform the interviews in this research, about 150 invitations were sent through emails to practitioners and educators from different levels to discuss several stages in the process. Invitations were sent to BIM-related interviewees. The Lebanese interviews were performed live and in person. They have been conducted in English and Arabic languages depending on the interviewee's language ability. After that, they undergo translation before the analysis by an authorized translator. For the broad interviews, they were made through online platforms in English language.

a) BIM in Lebanese Interviews

The first stage was with practitioners and educators from Lebanon to discuss the situation of BIM within the education and the academia in order to fulfill the gap in the literature review about Lebanon. At this stage, the interviewees were selected from the practice field with architects holding many years of experience as they can relate to the overall BIM situation in Lebanon. For the academics, it was with professionals holding degrees related to BIM and expertise in BIM teaching.

The process of exploring the current situation of BIM implementation in Lebanon involved a series of interviews with 140 participants. The background of the contributors is categorized into three groups: engineers working in medium large-scale companies in Lebanon; tutors at Lebanese universities; and undergraduate students ranging from first year students to senior levels as shown below.

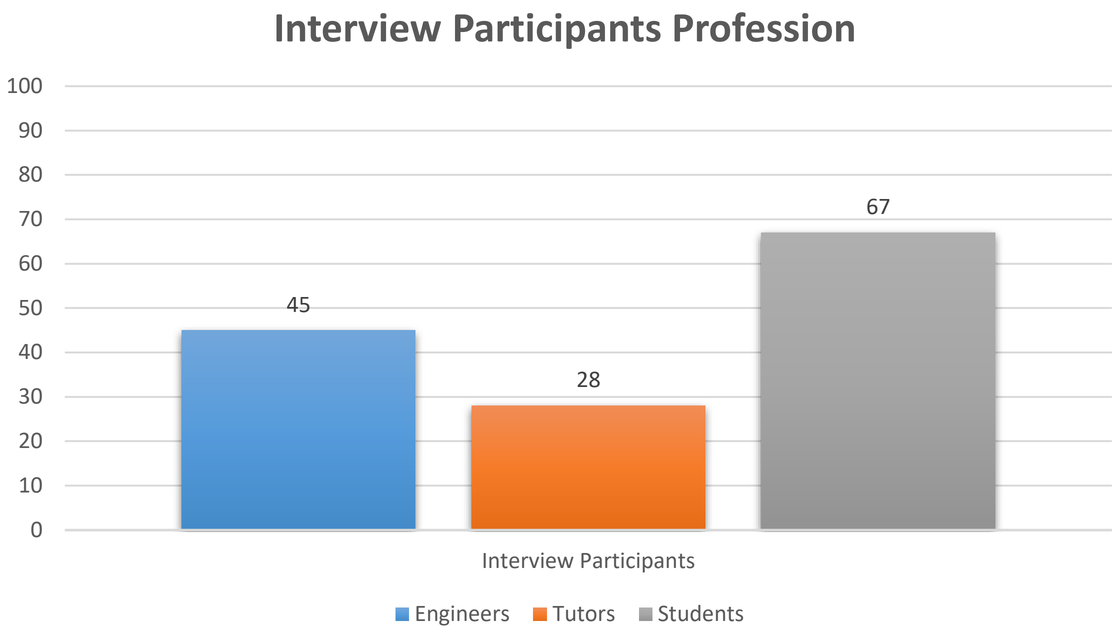


Figure 4-4 Interview participants professions

The core purpose of the interviews is to explore the participants' thoughts and points of view about the BIM status, knowledge, awareness, and implementation in Lebanon based on what they encounter from their everyday practical experience. The interview questions and discussions aim to answer the issues related to the gaps identified earlier form the literature review and those that act as a barrier for BIM adoption in Lebanon.

The process of interviewing the participants within Lebanon was quite easier than the international interviews. Being present in the same geographical location as the targeted participants allowed for the one-on-one live interviews and discussions with the different backgrounds of the participants. Engineers were interviewed post their working hours during a date and time convenient for the participant. Interviews with tutors were set during their presence at their offices at the universities. Students were majorly interviewed during their presence hours at the university or during their free time.

b) Guidelines interviews

Then the second interview was to gather information about the appropriate methods of implementation, previous experiences, challenges, and solutions. This part was made with professional academics from UK and Lebanon; they were experts and had previews experiences in teaching and implementing BIM. To add more value to this stage, part of the interviewees were related to the accreditation parties: RIBA and NAB.

For the purpose of achieving the objective of this phase, the selection of the interviewers was based on the criteria of achieving the previously mentioned goals, where the participant's background had to be compatible with the interview type of questions. Out of 37 personnel invitations, only 11 responses were obtained varying between practitioners and professional academics. The professions of the 11 interviewers are listed in table 3 below. The whole interview process followed a professional approach, where the invitation took place via a formal email and official approvals were sent back and documented. The time frame for the interview was approximately half an hour, performed face-to-face or through video calls for international participants.

Interviewee	Profession
INT 1	PhD Architecture – Teaching Filed
INT 2	PhD Architecture – Teaching Field
INT 3	PhD Architecture – Teaching Field
INT 4	PhD Architecture – Teaching Field
INT 5	Senior Lecturer Arch – Teaching Field
INT 6	PhD Architecture – Teaching Field
INT 7	PhD Architecture – Teaching Field
INT 8	Senior Lecturer Arch – Teaching Field
INT 9	Senior Lecturer Arch – Teaching Field
INT 10	PhD Architecture – Teaching Field
INT 11	PhD Architecture – Teaching Field
INT 12	Senior Architect – Practitioner

INT 13	Senior Architect – Practitioner
INT 14	PhD Architecture – Teaching Field (Part in RIBA accreditation Lebanon)
INT 15	PhD Architecture – Teaching Field (part in NAAB accreditation Lebanon)

Table 4-2 Interviewees Table

The main structure for the interview was the English language, whereas participants in the region of the Middle East preferred the native language. Their responses were all translated into the English language and approved again by the respondent. The main focus of the interview with the practitioners and the academics was concerned with the learning objectives, the requirements of implementing BIM in the architectural curriculum and engineering sector, and the type of recommendations for the implementation framework setup. The responses all serve to answer initially the first three set objectives. Moreover, interviews with the practitioners sought to get responses about BIM's importance and its use in the industry. Thus, the selected participants of the practitioners were people who have used CAD tools and have experienced the transition to BIM use during their career.

To better understand the importance of BIM in the AEC industry, it was essential to examine the current market demands through the set job roles related to the architecture roles and their respective job requirements. This necessitated performing interviews with fresh graduates, ranging between 1 to 3 years, who are trying to set their way in the market. Here, the selected communication method is different, using various social media platforms, such as Linkedin, Facebook, Twitter, and Instagram, where it targets this age segment of the society. Also, interviews with students were performed at the university I used to teach at, where some graduates are still jobless.

c) Validation interviews

The last part was the validation stage. Its aim was to discuss the drafted framework with the interviewees from the second stage and later .This stage wasn't easy due to the COVID-19 pandemic situation that prohibited us from face-to-face discussions, where most of the interviews in this stage were performed online. The third stage was repeated twice to perform a second validation of the modified framework.

The process of validation started with an invitation to around 75 potential participants, where the following key topics were briefly outlined: the research topic, the importance of their participation, method of participation, the confidentiality and anonymity that shall be maintained at every level, and the estimated duration of a 20 minute-presentation and a 20-minute interview. 20 respondents were motivated to participate and be part of the framework validation. The interviews were performed face-to-face with the Lebanese residents and via an online Skype call with the UK residents.

The presentation starts with a short listing of the outputs of the literature review, the interviews, and the observations of the researcher's practical experience as a tutor which identify the existing problem. The researcher then explains the difficulty in considering a change in the structure of the existing curriculum and the motives behind developing a framework that can be adopted by any faculty of architecture and built environment within its modules.

The researcher starts by explaining the different aspects of BIM implementation and then moves towards a thorough explanation to the participant every year of the architectural curriculum. The researcher clarifies the type of module to be implemented and how (standalone course/ integrated). It furthermore specifies the time of semester in which it takes place and describes the expected BIM learning outcomes when implementing the module. By the end of the presentation, it starts with discussions related to the framework understanding and the feedback related to it. Below is a table that summarizes the coding of the interviewees and their professional background followed by the analysis of the interview findings.

Code	Profession	Code	Profession
Int 01	University Professor	Int 11	Practitioner , Instructor
Int 02	Practitioner , Instructor	Int 12	University Professor
Int 03	University Professor	Int 13	Practitioner , Instructor
Int 04	University Professor	Int 14	University Professor
Int 05	University Professor	Int 15	Practitioner , Instructor
Int 06	RIBA Board Member	Int 16	University Professor
Int 07	University Professor	Int 17	University Professor
Int 08	RIBA Board Member	Int 18	University Professor
Int 09	University Professor	Int 19	University Professor
Int 10	Practitioner , Instructor	Int 20	Practitioner , Instructor

Table 4-3 Interviewees table

The second section of the framework validation was dedicated to performing an actual implementation trial of the framework on 3 undergraduate architectural curriculums in Lebanon. The framework implementation was performed under the supervision of professional educators, who were previously involved in the study and interviews and who also act as contributors to the development of the curriculum at their university workplace. Following the implementation scenarios, further discussions were performed with educators to evaluate the outcomes and gather their feedback for the final validation results.

4.3.2. Group Discussions

A group discussion is based on communication where the researcher interacts with a group of respondents under their guidance and the participant's response generates influence and discussion between one another. For example, a group discussion can take place between a group of business experts and the researcher, where they define methods for identifying key performance indicators for measuring the organization's performance (Johannesson, 2012).

Group discussions with students were part of this research. One of the important issue with my research is that it was important to study all the parties of this implementation, from practitioner to educator and ending with students. Several group discussions involving students from several academic years were performed to discuss the situation of BIM from the student's perspective.

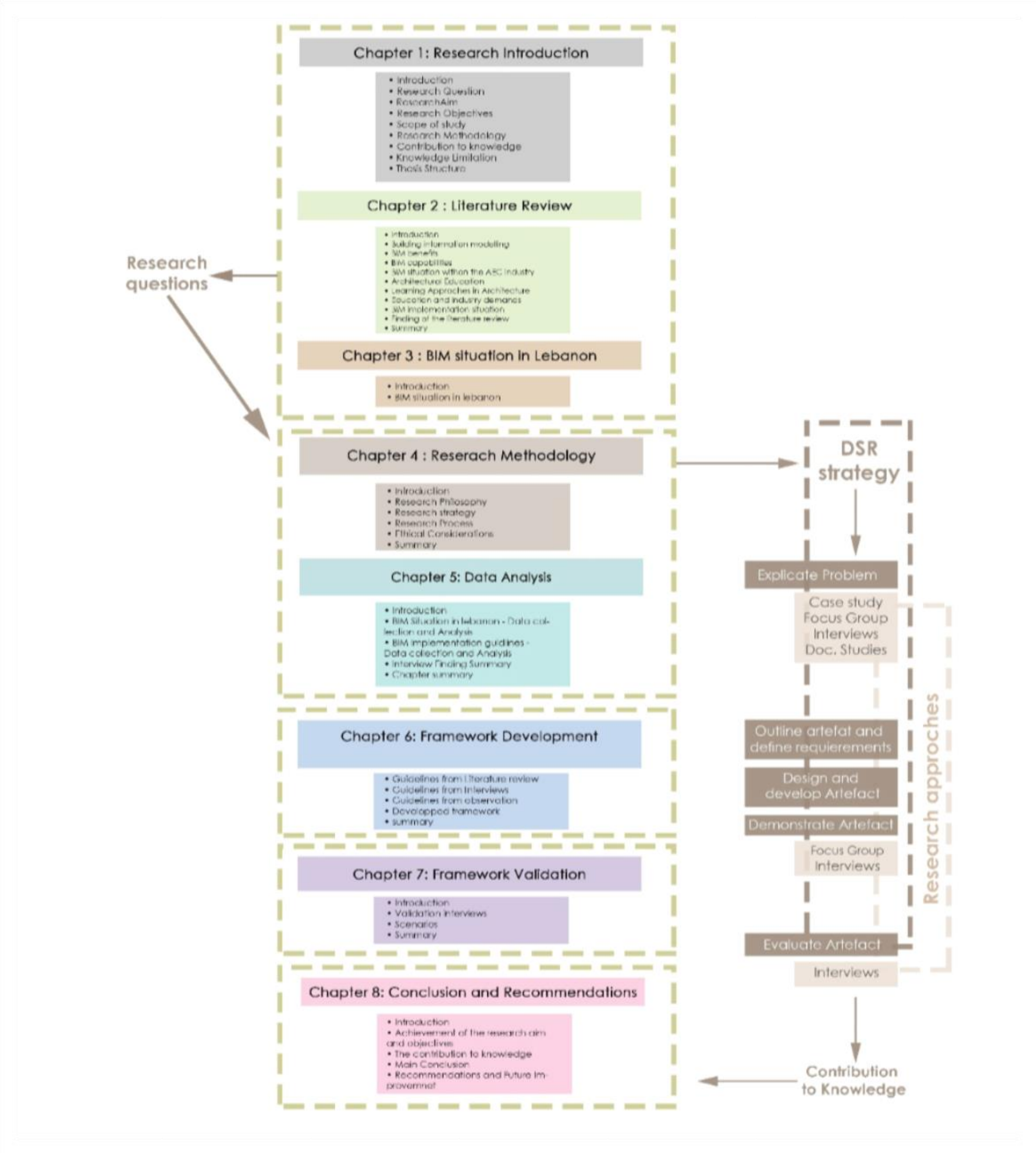


Figure 4-5 Research strategy

4.4. Research Process (Data Collection and Data Analysis)

The research techniques and process of data collection are important in order to ensure operation for the research and work methods that are set by the researcher. The process of selecting an adequate research technique is closely related to the type of data being collected, how and where it can be found, and who can collect it.

In this research, the process of data collection focused on two methods: interviews and observations. This balance was necessary in order to fill the existing gap from the analysis and findings of the literature review.

One form of data collection that investigates an existing situation or problem is the interview. According to Dicicco-Bloom and Crabtree (2006), interviews can be classified into two types:

Standard or Structured Interview: the interviewee defines and follows a pre-structured set of questions. The interviewers might wish to modify the questions based on the response of the participant.

Non-standard or non-structured interview: the interviewee formulates their questions based on the development of the discussion. Questions here are open and take an informal form of discussion.

One of the greatest opportunities that the interview tool offers is the flexibility in rephrasing questions, which provides better understanding for the participant and therefore accurate collection of data that is not found in a bibliographic source (Saunders et al., 2012). On the one hand, when the interview takes place in person, it is easier to read the attitude and expressions of the participant during the answering process.

On the other hand, disadvantages may appear in the interviewing process. This is mainly concerned with difficulties in communication between the interviewer and the participant when it comes to the interpretation of the questions or answers. It is important that the researcher is unbiased to any view (Saunders et al., 2012). The information provided by the interviewee may be important so that they might choose to withhold it. Here, the researcher has no control over this situation.

Interviews in this research were divided into three categories. The first one was the information about the Lebanese BIM situation, where the collected data was picked from the interviews without our interference, comparison, or in deep words analysis in order to relate the situation and objective as can be. As for the second category, it was more about opinions, facts, and guidelines for the presentation. In this category, it was important to deduce a certain pattern from the text of all the interviewees and to analyze the key words and relate them to the empty spaces I need to fill within my framework design. This procedure resulted in a structured guideline with the essence of the ideas gathered from these interviews. In the third category, answers were clear and direct to the point. The analysis was based on deducing the scientific points from the subjective opinions of the interviewees.

4.5. Ethical Consideration

One of the most important aspects of a research is the criteria taken to maintain ethical consideration. Bell and Bryan (2007) specify the ten main features that must be present in the principles of research. These are highlighted below and are applied to this research:

2. Participants in the interview or the research are not subject to any harm.
3. The dignity of the participants is a priority.
4. Prior to performing any interview, full consent is obtained from the participant in a written form, which is found in the appendix section.
5. The privacy of the participant is maintained whether through the communication tools or data storage.
6. All research data shall remain confidential.
7. All participants in the interview are represented as anonymous
8. The aims and objectives of the research are far away from any form of exaggeration.

9. Any affiliations participating in any form have to be declared.
10. Ensure that communication with participants is in a transparent and honest way.
11. Ensure that there is no misleading information or any biased data.

4.6. Summary

The chapter explained the adopted research design and methodology applied in the thesis. The research process was compared to the example of the onion model described by Saunders et al. (2012), which filters the process through consecutive layers. The first section covered the research philosophy and the knowledge modes emerging from the industry. The second section covered the research approach characterized by its utilization in the validation of the shift from the traditional method towards BIM. The third section discussed the research strategy which was the design science research, since the research builds on answering questions emerging from artefacts. The section also outlines the selection of the research methods used for this purpose, which were: semi-structured interviews, group discussions, and document studies. The fourth section explained the data collection process, which focused on two techniques: interviews and observations. The final section of this chapter outlines the ethical considerations adopted in the research.

Chapter 5 **DATA ANALYSIS**

The findings of the performed interviews by the researcher are discussed and analyzed in this chapter. The core objective is to assess the current situation of BIM implementation in the professional and academic fields in Lebanon. The results of the semi-structured interviews performed with professional practitioners, tutors, and students of undergraduate and fresh graduate levels are all represented in quantitative rates and qualitative highlights. The outcome of this chapter is a set of guidelines for the BIM implementation framework development coming in the following chapter.

5.1. Introduction

Research methods in the aspect of social science research are considered an essential part in determining the success, validity, and reliability of any research project. The interest in understanding human behavior is defined by social scientists in the use of qualitative research in order to better understand the overall context (Rubin & Rubin, 2005). The qualitative aspect of the research seeks to describe the quality and nature of people's behavior and experience rather than recording numerical data. According to Brown (2005), the greatest strength of qualitative research is its ability to form hypotheses. Dörnyei (2007) similarly notes that the common method for collecting qualitative data is through interviews and questionnaires. Still, when comparing both tools, interviews tend to be more powerful in gathering narrative data, which allows the researcher to further investigate opinions in depth (Kvale, 1996). Similarly, Cohen et al. (2011) added that when using interviews for data collection, the method is more convenient in exploring and negotiating the construction and natural contexts.

The process of collecting data for this research took place over a long period of time. Since the start of the research and after being granted the ethical approval, the observation process towards the everyday real-life educational and professional experience has been the focus of collecting data for this research. As a researcher, the exposure to the educational field as a university tutor and a practitioner in the professional field has widened the depth of data collection of this research; being the direct and reliable source experiencing the everyday technologies, their impacts, problems, and opportunities. This allowed the researcher to identify the real gaps that exist, assess the implementation of BIM in the educational and professional field, and therefore structure the framework which is best fit for the adequate implementation of BIM.

The method of data collection ought to be broad in its participants' selection beyond the territory of the study location. Online interviews and issue-oriented discussions were held through email invitations followed by video or voice calls. Yet, the number of respondents remained limited. The method for collecting the data necessitates more on-site observations and discussions, especially when it comes to assessing BIM status in Lebanon. This was achieved through a series of semi-structured interviews that took place during the daily experiences and discussions that occurred with students, colleague tutors, and practitioners. Some of which were planned ahead of time, mainly in the case of tutors and practitioners due to their free time. Other discussions occurred spontaneously, mainly with students, as their live interaction is accessible during university studying hours or after.

The whole data collection process can be perceived as a systematic work that observes, inspects the realities, and restructures the theories and applications. Between the semi-structured interviews and the oriented discussions, the method of data collection has built a strong and reliable base for the research and has eased up the analysis and formulation of conclusions.

5.2. BIM Implementation Guidelines – Collected Data

5.2.1. Semi Structured Interviews Data Analysis

The process of qualitative interviews tends to generate a large amount of data, where one hour of an interview needs around six hours to transcribe on fifty pages (Neuman, 2007 and Dörnyei, 2007).

The purpose of the interview was to go in depth into the questions generated from the literature review or where gaps were detected in the area of the research. The structure of the interview was built on categorized questions allowing the filtration of answers under different themes in the analysis process. The nature of the interview was a semi-structured one which maintained the freedom for the participant to express their opinion freely. Hence, the themes are similar from one interview to another. Yet, not all questions are standard depending on the nature of the discussion.

a) BIM Definition and Implementation Status

How do you define BIM within the academic field?

Int01 defined BIM as a process to generate the model and extract all the needed information from it. Int05 thinks that a BIM-integrated system includes all the stakeholders and the data they retrieve through a platform where all parties (client, consultant and contractor) share the information. Int07 believes that

> *"BIM is a very good tool for teaching in general, but it is not adequately used or well understood which presents a main problem".*

In addition, Int07 believes that the correct understanding and implementation of BIM shall result in positive outcomes. This reflects that the definition of BIM is associated with what the user seeks from BIM use, which explains the presence of various definitions for BIM as subcategories falling under one main title of BIM as a whole system.

Int01 considers BIM as a collaborative tool which won't replace neither people's imagination nor their environment. Int05 believes that BIM is the future of companies and drawing software, where all companies are on the way of adopting BIM. Moreover, he thinks that the architecture processes will become more integrated with the technology in the project's different aspects like cost, programming, and energy. Int11 believes that architecture technology needs a new approach in the teaching curriculum, especially at a time where market demands shape the new needs of teaching

> *"If the market has already demanded BIM and we ignore this demand then we will fail for sure."*

Is BIM for modelling and design implemented where you are teaching?

This question was targeted at tutors in the academic field. Almost half of the respondents expressed that BIM was implemented at the universities where they teach. Int01 stated that BIM is introduced as a REVIT tool in the first year of the architectural program, where students learn REVIT through their design development. Int01 highlighted that she tries to raise awareness about BIM being more than just a tool for design, but rather a tool to include information related to elements and schedules. She also requests students to do an energy efficiency model for the building. Int06 & Int07 stated that

"BIM is implemented partially at the faculty they teach at, where the concept of BIM is dealt with in teaching as REVIT course, yet it is not practically applicable in the design studio."

For instance, Int10 stated that BIM is implemented at the postgraduate level of the architecture program. Int11 stated that the faculty attempts to do approaches as a technology but does not teach BIM as a process. Int11 highlighted that

"We address BIM software tools but we don't address it as a process".

For instance, Int11 thinks that the faculty is implementing BIM but not in the way it should be implemented.

Do you currently teach within a multidisciplinary system? If yes, how are the disciplines connected to one another?

Int07 & Int08 recorded that they currently don't teach BIM within a multidisciplinary system. Int07 thinks that teaching BIM in a multidisciplinary system would be a favourable option, especially at the final years of study, where it adds a lot of experience for students. Furthermore, he highlights the idea of collaboration between students from different disciplines have already been implemented within the final year, so it could be easily applied on the level of BIM since it would be a replica for the practical working field. Similarly, Int08 believes that *“the real advantage of BIM is to use it in multidisciplinary system”.*

On the other hand, Int01 & Int10 have experienced teaching BIM within a multidisciplinary system. For instance, corporation occurs at the level of the second year where students have to corporate with building surveyors, quantity surveyors, construction project managers, real estate managers, and property management students. Int11 recorded the use of BIM in a multidisciplinary system at her university where students perform BIM analysis in level five during their graduation, which requires them to work with students from other disciplines like quantity surveying, management, and structure.

b) BIM Limitations and Disadvantages

Does BIM limit the imagination and creativity of the students?

Opinions were divided between participants who believed that BIM limits the creativity and imagination of the students and those who think otherwise. The first group supports the idea of BIM limitations to the creativity and imagination of students, where they tend to simplify their design ideas when they are incapable of translating them through BIM. As stated by Int01

“Yes it is limiting the creativity because they cannot handle the tool so what they can do is that they don’t design”.

Also, others support the idea of implementing BIM in advanced stages in order not to form a limitation to the students when designing. Int06 thinks that:

“the key in BIM is to allow a space for creativity especially at the initial phases of the project when it comes to design”

Moreover, Int06 considers BIM awareness to be the most important detail where students need to acquire the basic sketching and manual tools to represent in the initial phases of the project development and then move to BIM:

> *"the awareness in using BIM in early years is important so that BIM does not replace the manual skills and material knowledge and understanding"*.

Similarly, Int07 thinks that it is important for the student to master the tool up to a professional level in order to express their creativity easily. Yet, Int07 thinks:

> "the problem is that until now BIM software is not developed fully in a way that allows students to do models first and then transform them into plans, which is the hybrid learning method".

Int09 highlights the pedagogical approach in implementing BIM:

> *"there is a pedagogical need to slow down and introduce steps and meaningful stages to construct the body of knowledge about BIM."*

Int02 sees that the main disadvantage appears when:

> *"the student is used to software-generated drawings whether using BIM or 3D max, etc. His insight to estimate proportions is somewhat vague".*

He advises students to start with the manual-sketching process and then move to the computer-aided tool to develop the idea, where he would have acquired a better insight and feeling towards the proportion of his model.

Another point of view believes that it depends much on the student's motivation to push themselves out of their comfort zone and learn something new, regardless of when and how the software is implemented. Int04 says

> *"There are some students who start with an idea and end up with a simplified one and hence the BIM tool becomes their excuse of changing or eliminating their design ideas but there are the ones that push boundaries. Therefore, I think there are both types".*

Int08 furthermore supports this idea quoting:

“I am not sure that I think it should limit”

This is because Int08 considers that the tools are available out there for everybody who is willing to learn through trial and error. He believes that the problem is more concerned with the issue of fluency, where students need to be able to use parts of the software more confidentially as in the UK case:

“Revit is the tool which more dominant and it is foremost for the graduates in employability”.

Int08’s approach suggests using BIM as a formal modelling tool to develop conceptual masses in Revit. In addition, he suggests moving forward in the modelling environment through using the powerful side of modelling structures to provide a conceptual framework on how to coordinate clear pedagogic stages of a curriculum.

On a practitioner’s level, Int12 believes that the biggest limitation for BIM is how it is seen as a friendly user, “If you have the knowledge and experience of BIM and others don’t have the same level, then the process of transferring information is difficult, hard here”. Problems with clients are mainly changes in design that occur every now and then, which act as a limitation to the engineer when most of the work is already done on BIM. Int12 has experienced problems when inserting a certain data since a technician’s support is needed to customize the needed tool. Similarly, Int13 thinks that the challenge relies in the development of the software by non-engineers, where during implementation capturing technical information is still inflexible. Another challenge is dealing with non-BIM users or users who have basic knowledge of BIM and their adaptation to BIM technology in a short time.

“As CAD used to be a universal language between engineers, BIM should be another unified language to ease the communication across all”.

What are the disadvantages of BIM implementation?

For Int04, the most important feature is to be aware of BIM capabilities and what it can offer along with:

"the need to prepare them for the market".

Int09 considers that there are no disadvantages for BIM, yet he thinks that:

"we have to get to a position where we see hand drawing, physical model making, and BIM as part of a broader tool set".

Int06 sees that there is no need to talk about disadvantages since:

"the system is in continuous development".

Similarly, Int01 quotes how:

"Technology changes therefore relatively what you teach will be at some point out of date"

Therefore, students spend time learning things that they don't need to know since technology is facing rapid evolution. The key is to give students the ability to change and learn:

"We cannot give them everything that they need to know but we can give them the skills and the attitude to address new problems and learn new things".

Ideally, when students leave university, they get to a point where they are self-learners. They know the process to go through and get the knowledge they need to do that. Int07 considers that the software is causing students not to think about what they are doing due to timing issues. She states main concerns related to BIM lessening student's skills in projection, easing up cheating methods, such as getting ready libraries, facing technical issues generated by hardware and computers, which cause delays in submissions and deadlines. Yet, she believes that the best option is that if they are trained to understand the tool well in an efficient educational process, then they are able to support their design ideas.

c) Implementation Strategy and Needs

At which level can BIM be most efficient when implemented?

Int05 and Int03 think that the incorporation should take place at early phases of education. As per Int05,

> *"they have to collaborate with building surveyors, quantity surveyors, construction project managers and real estate managers and property management people"*.

Int10 believes that implementing BIM in early years, the second year, will not allow the student to fully make use of the software capacity; especially since BIM application requires high levels of creativity, design, and experience. This is mostly attained in the final years of study using programs that require a high level of experience, such as Revit and ArchiCad. Hence, he supports the implementation of BIM in a correct way,

> *"it should be implemented in advanced level students (4th and 5th years). This is because BIM incorporates 6 or 7 dimensions including green BIM, time management, budget planning"*.

Until the student covers all these aspects, it would take him until the 4th and 5th year of study to be ready to fully implement BIM.

Int08 thinks that in order to implement BIM adequately, it should be implemented in the final two years. In his opinion, since BIM incorporates 6 or 7 dimensions, including green BIM, time management and budget planning, it would take students time to cover all these aspects, which would be unattainable before the fourth year of their architectural program. However, Int08 thinks that BIM can still be applied partially in the early years of the curriculum.

Int01 highlights the fact of the existence of books that provide guidance for BIM and design; nonetheless, there is no fully-developed data that explains the whole process and delves deep into the details. Moreover, Int01 thinks that there is a whole urge for architecture education to move into a digitally-enabled system where:

"the starting point of architecture education is not digital but in reality that is the way the industry is moving".

When it comes to professional working institutions, Int12 and Int13 see that BIM use has reduced problems that used to arise from the site construction.

"BIM gives you an accurate and realistic model".

BIM is practical when performing updates and changes to the model, because any error that arises is quickly highlighted to the concerned party for fixation.

Another issue is that BIM is taught as an elective course in the 4th and 5th year, which doesn't allow students to have enough time to practice before implementation. Even when it is introduced in early years, it is limited since understanding the tools is related to the student's involvement in the architectural knowledge, which is still considered at a basic level at this point of study. Hence, by the time they reach their senior years, they tend to forget what they have learned about BIM in their early years as a matter of not directly practicing the tool, so they prefer to stick to the CAD tool. Int07 highlighted the importance of BIM knowledge by the staff members in the first place.

What is the suitable method to implement BIM; Standalone or Integrated?

The question is based on the experiences of the interviewees in assessing if the performance of BIM turned out to be more efficient, when implemented as a standalone course or when integrated with multi-disciplinary courses. Views have varied between both approaches; there is no right or wrong way of implementing BIM; the key is in the framework of implementation.

Int06 considers that the implementation of BIM is related to learning the pre-requisites and architectural basics first in order to introduce BIM later,

> *"the best way is to introduce BIM as a standalone course in the early years until we attain full integration in the 4th and 5th years"*

This is linked to the student learning pre-requisite courses and architectural terms that allow them to better understand BIM system. Int08 considers that modular course structure necessitates:

> *"there should be aspects of BIM in many modules rather than a dedicated specialist area of work".*

The integration process could take place across the program in different ways and might not necessarily be named as BIM. Int09 says that

> *"BIM is part of understanding digital tools that are available for architects in the 21st century".*

On a practical level, Int12 and Int13 think that BIM has minimized the technical errors that used to appear in different disciplines using the traditional method. With the use of BIM as a collaborative tool between multi-disciplines, it is easier to check for any design clashes between different systems and report them directly.

How could BIM serve the design-related modules in the architectural curriculum?

For Int07, implementing BIM in the design studio courses shall aid students in generating the conceptual model. It allows the student to visualize the spaces better than any other 3D software, since it gives the option of switching between the model, layers, and floors. Therefore, students can quickly do the circulation cores and clarify the concept idea. Int10 thinks that even though there are books that provide guidance on BIM and design, yet there is no guide that explains the whole process in details. Int10 believes that:

> *"there is a whole urge for architecture education to move into a digitally-enabled system. The starting point of architecture education is not digital, but in reality that is the way the industry is moving."*

Int03 thinks that:

> *"BIM aids in generating the conceptual model and visualizing its spaces better than any other 3D software".*

BIM allows the quick visualization and circulation within the model for a better clarification of the concept idea.

Also, Int09 is impressed with the Arabs example of how they have recently put out a software engineer that deals with engineers to develop the program; this should be reflected in education. Int04 thinks that when students learn the technical part of the tool, they are able to use it separately with their design. The key is to know the capabilities of the software, be able to work with it, and know when and how to use it. Int01 supports the idea of in-course integration since BIM is mainly about:

> "3D modelling and this is applied through all design modules and not limited to a specific course".

What is the criteria to follow to implement BIM within the university?

Different ideas were suggested for the possible implementation criteria of BIM into the curriculum. Most interviewers agreed on the fact that BIM should be introduced in design-related courses. For instance, Int10 sees the implementation process as challenging, where BIM is currently being implemented in interior design studio courses where he teaches. Yet, he suggests involving it, too, in execution courses. As for Int05, *"I would say within a design studio, it goes back to the individual style of learning".*

Int05 believes that as long as the student is working on his own design project, then they are more motivated. This keeps them going towards learning a tool like BIM rather than the case of working on a preexisting design, where it's easier to give up. Int02 suggests that BIM should be introduced from the third term (second year), where the student would have acquired by then the main architectural basis and can better understand BIM software and start implementing it in their studies.

Similarly, Int01 supports student applying BIM use on their own project in the design studio at the third year level, yet it can be explored by the students in terms of how you develop the collaborative process. Int01 encourages 3D modelling to be taught in the first semester of the first year, where he thinks that

"it is important when people design buildings they get the understanding of the spaces they are designing".

Students may be introduced to Revit or Sketchup or ArchiCAD in the first semester, since it is useful for students to be aware of the different methods. The problem here is with the software vendors. As there used to be an Autocad lite version, maybe there should be a beginner's copy of Revit or ArchiCad, which is simpler and more advanced filtering for the menu,

"it is an easier version to use just like a baby tool".

Although the student will still go through a more sophisticated level, it is a first step towards learning the tool. Int01 suggests that the help menu should be clearer and more explicit, like having an automated online chat with a technician. The idea of Int01 is to have a central shared resource for all the questions and answers supported, where students can access the platform and get online support from another countries that develop expertise and help people.

Int01 considers the need driven by students would be more effective, "if you have students that are motivated and understand something that they need to work on, they will actually bring in those technologies into the program". Keeping the students motivated is the question of making them aware of what the industry is doing. When the students see that they can achieve a better and faster output, even if performed by a more complex tool, then they would certainly be motivated to develop and acquire this tool. Int01 highlights that first-year single-discipline development is necessary and suggests that in the second year collaborative multi-discipline scenarios should be adopted for three-year programs.

Int07 focuses more on the time frame given for implementation, where teaching BIM should take an adequate time. She suggests that instead of teaching BIM in one semester, it should be taught within one year or even one year and a half or two. Also, BIM should be incorporated in execution design courses in order to take care more of the details, and it should be implemented in the architecture design courses to extend the creativity in forms. Both parts are important for students to develop their skills in Revit, where it will act as a tool used in design and not vice versa. If the software forms any limitation for the student, then they would alter the design in order to overcome the limitation. However, if the student was an expert in the software, they wouldn't face issues that force them to change the design for the sake of the software's limitations.

The suggested criteria by Int07 take into consideration the limited time frame for BIM implementation. Therefore, it is better to gradually implement BIM from the first year up until the graduation level, where they would have acquired a professional level and more practical knowledge. The ideal scenario is that in the first couple of years, students learn CAD including the digital design (3Dmax & Rhyno) and therefore acquire useful experience in it as a background to introduce BIM in the third year. During the third year, the student will be learning parametric design and BIM in parallel. This year is considered the most important one since the student should have learned the technical tools along with the managerial ones, where a prime knowledge in architectural terms, execution details, project management, and bill of quantities are developed by then. The practical implementation of BIM is seen in the design and execution levels during the final two years.

Int07 adds that “when BIM is implemented within the design and execution courses, the student will acquire a professional level, good understanding, and real visualization to the masses” and “it will be a waste of time to teach BIM as a separate course and apply it post-graduation since he would forget what he learned”. She furthermore suggests that BIM should be incorporated in every subject, and a consultant, such as a BIM manager, should be assigned to be present during all the courses in order to make sure that BIM is implemented in the right way.

When implementing BIM on a working level, Int12 thinks that it is best to start learning BIM by self-efforts and then through professional training that results in the application of BIM on projects. In most institutions that are implementing BIM, the company is taking the responsibility to train the staff and start its use on all new projects.

What are the courses where BIM can be integrated?

Int03 thinks that it is impossible to implement BIM in the taught courses, since the main problem is that not all students acquire the same level of BIM knowledge and skills.

Int06 highlights that BIM is composed of different levels, where the most attained one is the 3D level. Meanwhile, the 4D and 5D are achieved through Revit, which is taught as a separate course. Int06 highlights that project management courses do not incorporate BIM, since the main learning objective is to teach students the basics of management and quantity surveying. These courses are mainly a single-term course and if the student was to learn, for example, quantity surveying through BIM use, the data will be generated automatically with one click, which means the student is losing the learning process of estimation and bill of quantities production. However, the awareness of the tool is essential to validate the manual results at the end of the reports. Yet, it is possible to implement BIM in these courses or in the student's final year, since BIM is part of these courses and enables students to generate the quantities of their project, after they have already encountered all the basics of the quantity surveying course in the previous year.

Int01 experiences BIM in the first semester of the first year as a fundamental course, where students get to produce the design manually for the first 5 weeks and then use Revit for the final output. Int01 sees that by this way the student would have worked out what they want, which may throw them some challenges when using the software so that they don't get completely constrained by the software tools. The only concern to take into consideration in the taught course is that software should not limit design thinking. Int10 has experienced both methods, thus his opinion supports that:

"the most successful method is to implement BIM within the design course or execution course".

Int07 thinks that it is possible to implement BIM in project management and quantity surveying courses, since they are part of BIM. He also believes that the reason behind not implementing BIM within these courses up till now is that the main learning objective is oriented towards teaching the basic theories related to management and estimation.

Is the need for a technician at the university to aid the students in conceptual massing essential?

Int04 states that:

"You cannot know what you can do unless you know the possibilities of the tool".

The architect is capable of using the available tools to shape the design accordingly, because they are the best people to translate their own ideas and not anyone else. Int05 adds:

> *"some of the best ideas are generated because they are implemented in a design software and not in somebody's head".*

Similarly, Int02 thinks that whenever the tool is within the hands of the student or the idea owner, it is more convenient to express it as it is imagined. Therefore, the students should have the knowledge and background of these software, especially during conceptual massing. The technician might not fully translate the idea, and the soul of the designer. Likely, Int07 supports the idea considering that:

> *"the student should have the basic knowledge and when any technical issue arise the expert professor will help him overcome it".*

Int07 sees that it's the era where parametric design is one of the main tools that cannot be ignored and where the manager won't teach the student everything, but rather supervise them.

Also, Int08 thinks that it is essential to have a technician supporting the students in conceptual massing at the university. Int06, as well, thinks that there is no harm when technical assistance is provided by expert tutors since students won't be fully aware of the software. Moreover, he sees that design thinking and aesthetic value are changing from one era to another and considers that:

> *"one of the BIM advantages is that it allows you to test the new aesthetic value when it comes to new forms and modelling".*

He further adds:

> *"in previous times, when 3D representation was focused on sketches and physical models, we used to help the student to*

develop his creativity and skills, hence the same applies using new technologies as BIM and others".

Int01 provided two perspectives on this topic based on his practitioner's experience and his own educational experience. From a practitioner's perspective, Int01 says that there is a struggle when it comes to understanding and learning the software; yet from an educational point of view he is aware that one cannot cover everything, therefore:

"students should know as much software as they can because from an employability perspective that will give them more tools".

What is your opinion regarding a summer internship program dedicated for BIM practice?

Int09 sheds light on the existing gap between the architectural education and the professional working environment:

"there is a pretty big gap in how are we teaching our concepts and what is happening at the office".

Out of his five-year teaching experience, Int08 sees software-based practices as being side to complete creativity and imagination. Moreover, he insists that a gap exists between shifting from university to actual practice. Hence, it is important to link teaching concepts to practical work experience.

Int05 thinks that it would be beneficial for students to see how practices work by spending some time in. Int05 suggests that the BIM internship program should begin at least the second year of the undergraduate program. Int10 compares specializing in BIM to specializing in a medical field. For instance, Int10 believes that BIM experience is attained when students target BIM companies in their internship practice and in their future job search. Int11 supports the idea of BIM practice in the summer but not before the completion of the second year, where students would have gained the required BIM knowledge. Int11 believes that students should be exposed to different phases of the project and various tasks in order to increase diversity. Int11 also recommends the training to be done in a work environment that uses BIM, where the student submits a report at the end of the training that explains how BIM has helped them or how BIM could be implemented practically in a better way.

d) BIM Post-Graduation

Do you think their post-graduation level of experience will be fair enough to start working?

Int01 believes that students are definitely ready to start working, yet education through the rest of their practical life never stops. The role of the university is to show students new technologies, but beyond that it's up to the student to master the practice. Int01 states:

> *"The university gives you directions and basics, but once you graduate it is necessary to keep up with the latest things and do some personal effort."*

Int10 thinks:

> *"we have to be careful that we don't confuse the level of BIM ability and the ability to detail our buildings."*

Which means students should know what they best excel at and should be able to create appropriate construction information for a complicated ability. Int11 believes that if students were taught BIM as a standalone course, then they would attain a professional level at the graduate year and not an expert level. According to Int11's opinion, to attain a professional and expert level more hours of BIM are needed, which exceed the ones that are in the existing curriculum.

Int08, Int07, and Int02 think that the ideal time for an internship is almost between the second and third years where they have acquired the necessary architectural knowledge and educational framework. Furthermore, it is advised to go for training in companies that already use BIM in their work. Int02 is a strong believer that:

"the training is acquired when they practice it during their studies".

Also, Int08 thinks that there should be mentoring schemes with the RIBA so that students get to see how practices work by spending some time in and allowing them to have an insight about the practice functions.

On the contrary, Int07 believes that:

"we should not encourage a monotonic type of a summer internship and specify one field of training only that is limited with BIM".

She highlights the fact that an internship should allow students to get exposed to different phases of the project and different tasks in order to increase diversity. Int07 suggests that the training should be done in a work environment that uses BIM, where the student submits a report at the end of the training explaining how BIM has helped them or how BIM can be implemented practically in a better, adequate way. For the case of advanced architectural level, Int07 sees that when BIM is taught as a standalone course at the graduate level students will attain a professional and not an expert-level. Moreover, she claims that to attain a professional or expert level:

"more hours of BIM are needed which exceed the ones that are in the existing curriculum".

Int04's point of view focuses on the process of life-long learning, where education never stops for any practitioner. The university basically guides students to the necessary techniques, but beyond that it's up to the student or the graduation to perform the practice, *"you cannot do much unless you spend hours on your own"*.

Int05 thinks that in the UK there is no variety when choosing modules. Moreover, Int01 considers that architecture shapes students that are suitable for any area of the industry. In his opinion, there is no specific introduction for a specialized typology, because the knowledge related to housing is different than the knowledge related to railway stations.

Int12 says that most candidates that are applying to the company have basic BIM knowledge and believes that its application on projects will come through practice and experience. Also, Int13 thinks that it is unnecessary for candidates to fully know BIM; the basics are what matters, and the rest will come through learning and practice.

5.2.2. BIM in Job Requirements

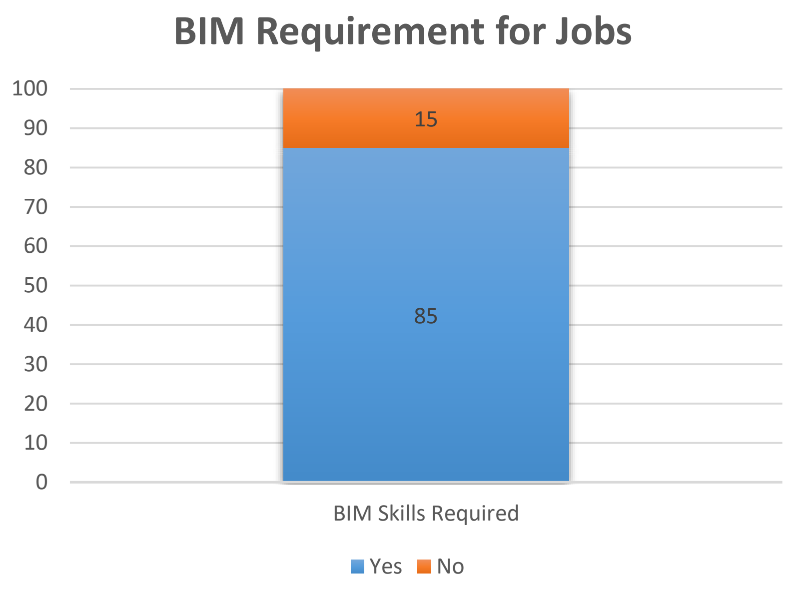


Figure 5-1 BIM requirement during job screening

12 students were interviewed in an attempt to examine what were the challenges they faced post-graduation. The results came similar to the reasons that stood as barriers. 85% of the students see that acquiring the knowledge and proficiency in BIM software tool acted as a barrier in their employment process. Most universities still teach CAD and 3DMax or teach BIM as an

elective course. In most cases, students end up self-learning BIM or not learning it at all at the university. For graduates who had enrolled with the company prior to its implementation for BIM, the company later took part in training its employees. Furthermore, he highlighted that they consider the time spent learning BIM at university to be insufficient and should be given through a period of one year instead of one semester. For the 15% of students, whom they didn't face this problem in their employment, they have learned BIM in the form of REVIT at the university and managed through personal efforts to gain more experience and strengthen their skills until they reached a professional level at the time of graduation. Although BIM supports different project teams to coordinate and communicate with one another, graduates who got employed with minor or no BIM experience didn't encounter a problem in dealing with other disciplines at work and managed to perform well.

Another issue that students faced was the requirement for certain years of experience. 90% of the students have complained about the requirement to have specialized experience for getting a job. The requirement was either in the form of having 3 years of experience, which does not take into consideration the fact that they are fresh graduates and the only experience that they might have been exposed to is through short-term internships. Graduates have considered this issue a contradicting one. How are they supposed to have a number of years of experience when they have just graduated? Graduates who have been trying to apply to countries outside Lebanon, specifically to the UAE region, were requested to have 3 years of experience in the UAE market itself. This issue was disappointing to the interviewers and they mostly ended up in drafting positions. Few were lucky to start employment in a short time or in another country; the reason was mainly due to their useful connections with someone working within the company they are applying to.

RIBA Accreditation Requirement – A Lebanese Trial

An interview held with Interviewer, 14 reflected the great experience of the participant with the RIBA implementation in the architectural curriculum in a university in Lebanon. When working to achieve an RIBA accreditation, the program was subject to changes in its structure and description, which mainly involved increasing the percentage of design-oriented courses to a minimum of 50% and updating the research techniques courses to become a mandatory one. Regarding the obligation of involving technology to be present in the criteria of the RIBA, Int14 says that

> *"The RIBA does not focus on the tools used but rather on the outcome where their main concern is to have an integrated design".*

When implementing BIM in the curriculum, it was as a standalone course since the focus was on how to serve the program itself rather than to keep up with the trend in the industry. BIM was treated as a drawing tool more than a whole system. Moreover, the implementation process has faced rejection from the teaching staff since they considered it has a negative impact on the students' creativity and imagination.

Int 14 believes that BIM should be implemented gradually within the courses from the first year along with the advanced senior levels and thinks that the problem with the RIBA is that we have many modules as single entities, whereas in the UK system the modules are merged together and there is a horizontal transparency between the courses. When integrating the RIBA to achieve accreditation, it was essential to resolve issues related to the integration of the courses and their relation to the practical field. For instance, the need to add more courses that are more related and direct to professional practice and the addition of thesis and research techniques courses.

When working on a criterion to elaborate the structure of the updated curriculum, Int 14 recommends having an inter-disciplinary program which aims to build up knowledge about all disciplines in the construction field. The result is a wide general knowledge of other disciplines, especially regarding technical issues and one integrated design. Int 14 highlights that

> *"The idea of this program is not new where 17 universities in the United States have already adopted it and it is accredited by ABOTS. The architectural programs in the UK and the US differ from the only architectural program found in the middle east in Sharjah University is the additional architectural design dose".*

Int 14 believes that the UK's example is a useful one, since it specifies the discipline and provides guidance after the third year towards a certain specialty. Yet, to implement this criterion, the professional code should be adjusted since it does not allow a graduate to practice architecture if they did not complete five years of study.

When recommending a criterion for the implementation of BIM in the Middle East, Int 14 advised considering BIM in the first place as a main requirement in any program. Moreover, the staff need to fully understand that BIM is not a drawing tool and have the ability and willingness to take advantage of the new tool being introduced and make the best out of its use. Int 14 highlights the necessity to have a modelling workshop by the RIBA and advises the presence of a specialized technician to assist students in any complications that might arise.

NAAB Accreditation Requirement – A Lebanese Trial

A discussion with Int 15, who teaches at another top architectural school in Lebanon and the Middle East, dealt with the National Accreditation Board; (NAB) accreditation in relation to BIM requirements. Int 15 highlighted that, as an accreditation body, the NAB does not go into the details of the curriculum structure but rather focuses on the process and its steps, whether it meets their basic requirements to obtain accreditation. As an accreditation body, the NAB relies on each institution to build its own curriculum within the requirements. Thus, the NAB performs its assessment based on the compliance of the curriculum along with its basic requirements. They assess the faculty's progress and achievement based on the faculty's developed curriculum in alignment with the NAB requirements. Moreover, before going to the assessment of the program, the NABS assesses the candidacy. Int 15 states:

"The candidacy is when you build your curriculum and you make sure that it meets the requirements".

Int 15 highlights the requirement for the achievement of certain aspects in the curriculum, which are: design aspects, technology aspects, and profession aspects. Moreover, Int 15 highlights that there is no specific requirement or reinforcement to use a certain software or tool in the technology aspect; he gives the following example:

"For example, if you decide to teach the environmental systems based on theory and exercises without any software involved, they tell you okay this is what your curriculum works on and there is no objection as long as it meets the requirements. If you decide to use a software for the environmental system course to calculate the heating and cooling loads, analyze the building envelope, etc. they would not object as well but at least they want to see that the basics of the requirements are met."

Also, Int 15 highlighted how BIM as a management platform is being resisted within the architectural schools in Lebanon by the top management team and not from the accreditation body, which does not object to BIM implementation. From his experience, teaching the professional practice course and since BIM falls within the management platform, he believes that currently the only part of the curriculum where the student can experience BIM is through the professional practice course. According to Int 15, the disappointing part is when students arrive at professional practice, where most of them are not familiar with REVIT or Rhino and do not have the slightest clue of BIM. Int 15 states:

"Students do not understand BIM as a management platform"

Int 15 further stresses on the requirement of time to introduce BIM within the curriculum, where he believes that the faculty does not currently have an adequate time to teach students BIM from a conceptual platform or to teach students REVIT course. So far, they have been able to explain to students what BIM is in terms of integrated project delivery. Thus, in Int 15's opinion as a tutor, he cannot request students at the professional practice course to deliver their project using BIM, for it is not a reinforced course within the curriculum and the level of BIM understanding and BIM skills vary from one student to another. If a student is a BIM expert at this level, it is a result of their own self-effort and not from the faculty's reinforcement within the curriculum. Int 15 believes if the case was the opposite, regarding the students' proficiency with BIM when they reach the professional practice course, then he would have requested from them to perform BIM-related activities as: detect clashes, perform simulations, takeoff quantities, perform a simulation of how you manage a project on site, calculate the construction cost, generate the project's time schedule, etc.

Int 15 adds:

> *"I have also tried to introduce BIM 5 years ago as an elective in a first step, but the dean of the faculty resisted its adoption and preferred its inclusion as a construction management course"*

Int 15 highlighted that BIM inclusion in the construction management course took place in the faculty of engineering only and students have proved their understanding of BIM, whereas the architecture students still lack the knowledge and understanding of BIM system, since no inclusions within the architectural curriculum have taken place. This created a gap between the project teams in integrated project delivery, where engineers of different disciplines have the knowledge and practice of BIM while architects don't.

5.3. Interview Findings Summary

This summary recaps the outcomes of the interview analysis and the filtering of the responses towards targeted themes that reflect similar views. Conclusions that are derived from the previous ones are summarized below:

- The first output is that BIM as a tool should be taught in the educational process rather than forcing changes to the whole teaching system.
- The second outcome suggests that BIM tools should neither limit the creativity of students nor replace their capacity to represent themselves manually. Therefore, careful consideration should be taken into account regarding when and how to introduce BIM.
- Respondents see time and manual representation tools as sketching that should be regarded as the initial conceptual phase prior to the development of the design through BIM tools. It is best to introduce BIM as early as possible, but not before the acquirement and practice of manual tools.
- Suggestions were made towards introducing BIM in the second year, where students have time to practice throughout their studies and can attain a professional level at the time of graduation. Integration and collaboration is one key to successful BIM implementation, where it is not limited to a specific course but rather applied to all modules that are design-related. This aims to be a replica of the working environment in the educational field.
- As with any new tool, BIM presents some disadvantages. Recommendations by professionals suggest that BIM tool is used efficiently when students fully understand the tool and use it to support their design ideas in the phase of development, in order to maintain their skills in sketching and visualizing proportions.
- Experts believe that the student is the best source for providing their own input to the software and expressing their own ideas. Eventually, the student will acquire new skills with time and have the ability to solve their own problems. Yet, technical assistance can be provided at the level of

education or through an online platform at the level of the working environment.

- Professionals also agree on the idea that BIM should be as close as possible to the real-life working process. Therefore, they support the idea that BIM architecture education should shift towards the way the industry is working. The implementation of a collaborative exercise between different engineering disciplines at the senior levels in education is thought to be the best time for students to explore the flow of the whole process.
- When it comes to acquiring BIM experience, professionals believe that this process is self-built through personal efforts, whether through training programs, internships, and practice.
- As for BIM implementation in the curriculum, it is recommended to involve BIM in the design and execution of courses within a reasonable time frame at an intermediate level.
- It is important for students to have acquired a fair amount of architectural knowledge in order to better understand BIM and be motivated to put their personal efforts into the new skills development. Moreover, tutors believe that BIM requirement within the program ensures its implementation by all universities in their process to upscale their quality of learning and stay within the competitive level.

5.4. Chapter Summary

The chapter presents the outcomes of the collected quantitative and qualitative data. The first section, which is concerned with the quantitative data, examined the background of the current situation of BIM in Lebanon concerning the awareness of BIM and the level of maturity through interviewing professionals, tutors, and students. The results revealed that almost half of the practitioners were aware of BIM concept rather than the whole system and had practiced BIM in their working environment. The conducted interview results by the students revealed the limited adoption of BIM at universities, with only 18% of students having BIM awareness mainly through their senior years of study. BIM was majorly seen as a REVIT tool by students and acquired through a standalone course. As for the interview results collected by tutors revealed that around 90% have BIM knowledge but with varying levels. Another quantitative data assessment was performed on a total of 13 undergraduate architectural curriculums in Lebanon through analyzing the course structure and contribution to the whole program during the 5-year period. Results conveyed that the design studio modules constituted 30% of the program structure with only 20% implementing BIM as a single standalone course in the form of a REVIT tool. With a moderate to high awareness level of BIM by students and tutors, the minor adoption of BIM by academic schools is suggested due to the stacked curriculums, the expenses of implementation, and the lack of BIM implementation guidelines.

The second section of the chapter evaluated the qualitative outcomes of the semi-structured interviews performed with professionals, tutors, and students concerning in-depth BIM implementation status. The findings of the interviews could be highlighted with the following ideas. Professionals and tutors agree that BIM offers great support to the processes of collaboration, visualization, reduction of errors, analysis, and efficiency. Interviewers emphasized the urge for its implementation, especially at senior levels. They also expressed their concerns related to BIM limiting the creativity of the student and the need for technical support for complex modelling. In addition, they highlighted the importance of having the awareness of BIM capabilities from early years and developing its skills to better prepare students to withstand the demands of the market. Furthermore, interviewers supported the implementation of BIM within the design and execution courses through a gradual approach during the 5-year period, where the student is expected to acquire a professional level, good understanding, and real massing visualization by the end of the graduation year. Interviewers further encouraged the obligation of students performing summer internships at companies which support BIM to gain more experience. They also highlighted the lack of any accreditation that imposes BIM implementation on institutions. Finally, interviews with graduates highlighted the problem of the market demanding BIM skills for fresh positions in the absence of an educational program that supports and develops this requirement.

Chapter 6 **FRAMEWORK DEVELOPMENT**

The efforts of gathering and analyzing the data from the literature review and the semi-structured interviews are translated in this chapter. The outcomes of the previous chapters are used as guidelines to formulate the proposed framework for BIM implementation, particularly in Lebanon and other parts of the world.

6.1. Guidelines Derived from Previous Chapters

6.1.1. Guidelines from Literature Review

L1- BIM is more than a drafting tool: For a number of engineers, the concept of BIM was limited to its use as a drafting tool in the form of REVIT. Nevertheless, the literature review section conveys different capabilities for BIM that could be incorporated within the architectural curriculum. These capabilities are represented in the figure below and are efficient when they are looked at from the phase of framework development. (Literature review section 2.2 ; 2.4)

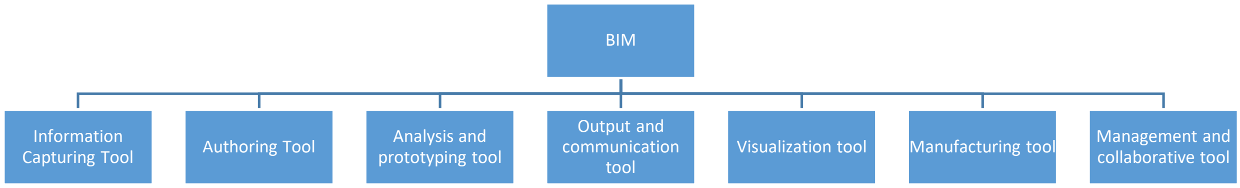


Figure 6-1 BIM capabilities

L2- The importance of BIM: It is necessary to understand the importance of BIM as a whole system, in order to know where and how to use it and take optimum advantage of its benefits. When BIM experience is involved in the knowledge process, as in the example of NBS report, using BIM becomes a favourable option for the engineer or the institution. On the level of students, it is important for them to know about the existence of the BIM system and how they can use it to achieve their educational and representational needs through theoretical courses. (Literature review section 2.4 ; 2.9.2 ; 2.9.4)

L3- BIM is the language of the market: BIM is dominating the market and this is conveyed through the data provided in the reports presented in the literature review. It is important to let students be exposed to the needs of the market through internship programs or site visits during their study period. This shall allow students to keep up to date with the latest trends in the industry and prevent the existence of a gap when shifting from the educational field to the practical field through building up knowledge about BIM background. (Literature review section 2.5 ; 2.7.3)

L4- Learning theories to adopt a safe landing of the BIM implementation:
In this section, the main points that shape the learning theories are examined in order to link each one with the achievement of the objectives in the implementation process. One of the most important systems in architecture now is the PBL system. BIM allows the user to have a real-life perspective, which enhances the user's experience, especially regarding the sense of proportions and space. (Literature review section 2.6.2 ; 2.9.2 ; 2.9.7)

L5- Today's industry is lacking fresh graduates who have the exposure and experience in BIM system. It is necessary that the graduates have the basic BIM knowledge, so that they have higher chances in being candidates for job vacancies. (Literature review section 2.5.1 ; 2.7.3 ; 2.9.6)

6.1.2. Guidelines from Interviews

I1- BIM should not replace the conventional hand skills: The implementation of BIM should be a continuity to the existing courses that support the manual skills. This shall not interrupt the sense of architecture for students.

I2- BIM should be implemented for students in an early stage: the optimum time for the introduction of BIM for its implementation is just after the acquisition of students to the manual skills, so that they don't miss the true architectural meaning in experiencing manual hand drafting and sketching skills.

I3- BIM-mixed method implementation: it is important to implement BIM in theoretical courses as well as separate modules. Yet for full BIM benefit and production, it is important students apply what they learn in all possible modules that can incorporate BIM-like project management and quantity surveying courses.

I4- Understanding BIM tools: It is vital students understand BIM systems from all perspectives and know all the tools that can enhance their skills and enable them to better translate their ideas and concepts into high-quality visual representations regardless of the complexity.

I5- Technical assistance / BIM hub: The tools of BIM are vast and broad. No matter how much BIM is incorporated into the architectural modules, it won't be fully covered from all of its perspectives, since it remains a part of a whole system. For this purpose, it is important for a BIM technician to be present in order to assist students in translating their complex ideas and help them in exploring the BIM tool more. Furthermore, a BIM learning hub is a great option to share all BIM users' experiences, especially when it comes to problems and how to solve them. This shall ensure a soft shift from the CAD system to the BIM system.

I6- Senior collaboration: It is important to reduce the gap between shifting from the university experience to the working experience. Introducing BIM into the educational curriculum as much as possible, ensures a safe transition from the educational level to the working level with minimal challenges and barriers. Therefore, collaboration between different engineering disciplines at the senior level is essential to replicate the working environment case.

I7- BIM design and execution relation: BIM different levels shift between design and execution modules. Design models of a project are generated using BIM. When it comes to execution, BIM allows a high level of detail through its tools and systems.

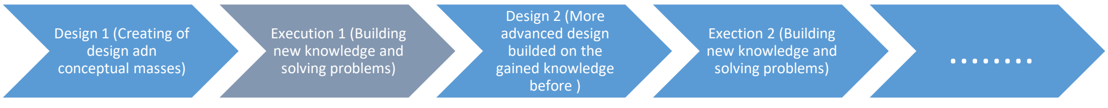


Figure 6-2 Design to execution relation diagram

I8- Credited internship / counted experience: The best way to practice theories taught during the study period is through direct application in internship programs. This allows students to experience what they learn in a short time rather than forget it after a while.

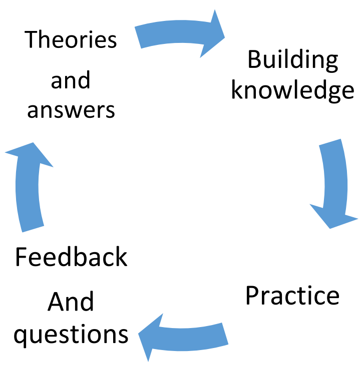


Figure 6-3 Visual knowledge cycle

6.2. Developed Framework

This framework aims to ensure a safe and smooth implementation of BIM within the curriculum while maintaining the initial initiatives set within. This framework shall act as an enhancement to the existing architectural curriculum, which aims to adopt BIM gradually within its 5 year-structured program. Three main key elements need to be taken into account during the application process. The first one is the BIM aspect, which guides the type of module involved in the process of implementation. The second element is the scale of BIM which will be reflected during the implementation without changing the design process. The third key element is the relation of BIM implementation to one of the BIM maturity levels in order to ensure the framework implementation is up to the international standards.

6.2.1. BIM Aspects

- Theoretical aspect: When BIM is first introduced to students, it's in the form of a theoretical standalone course that delivers the basics of the system **(Guidelines I3, I4)**.
- Tool aspect: for students to master the BIM system, they should have the minimum knowledge related to the software which enables them to use BIM tool easily and flexibly **(Guidelines L1, L2, I4)**.
- Practical aspect: in order to assure that the students have understood BIM theoretical knowledge, it is necessary to translate what they have

learned into practical application. The process of application takes place on three levels: object level, project level, and detail level **(Guidelines L3 , L5 , L8)**.

- System aspect: after the coverage of all previous three aspects, the final aspect of BIM is the integrated system reflected in the graduation project **(Guidelines L7)**.

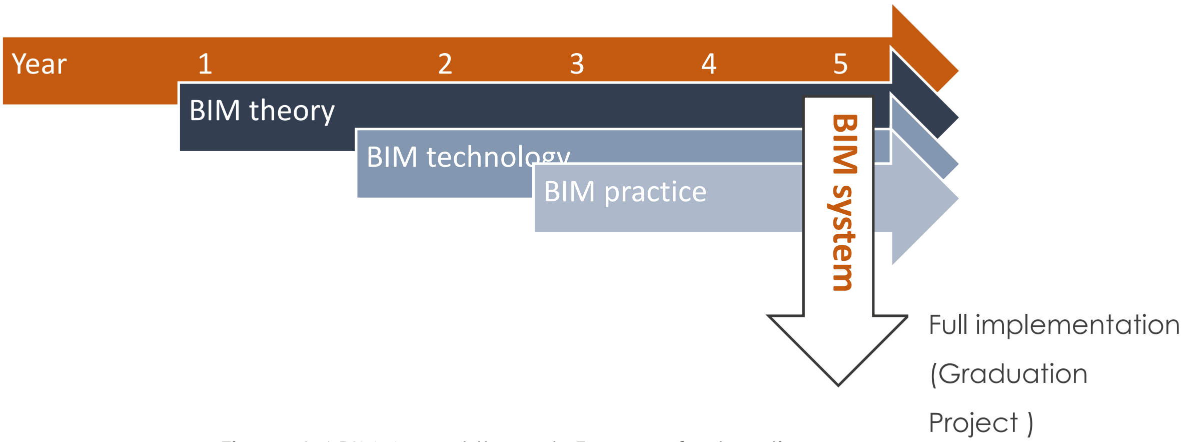


Figure 6-4 BIM Aspect through 5 years of education

The implementation of BIM starts in the early years of architecture in the form of introducing BIM theoretical courses in the architectural curriculum, in parallel to the foundation course of the architectural education that relies on manual skills. **(Guidelines L2, L4, I1, I2)**. Once the theoretical part covers the basic terminologies of architecture, a separate BIM support module emerges. It teaches students BIM technology and its uses until they reach the second year level **(Guidelines L1, I3, I4)**. After two years of knowledge and theoretical acquirement, students at the beginning of level 3 should be ready to practice BIM on small-scale projects in the design module and within the internship program during summer time **(Guidelines L3, I5, I7, and I8)**. By the 4th and 5th years, students should be able to make use of all of the BIM theories, tools and practices in one whole BIM system. A system that exposes them to real-life projects and requires them to submit full BIM-generated drawings and reports, that ensures their maturity level in BIM systems and knowledge prior to their graduation and exposure to the working industry **(Guidelines L5, I6)**.

6.2.2. Framework Development

a) Implementation Aim

This program aims to realign the learning outcomes for a BIM-based architectural engineering curriculum in compliance with the industry needs and requirements.

b) Implementation Objectives

In parallel to the architectural engineering objectives and learning outcomes, this framework stands as an addition to the program in incorporating to the overall curriculum the following represented technological objectives:

- The ability to graduate from the university with an overview of the most recent technological upgrades within the AEC industries, including BIM. **(Guidelines L2 , L3)**
- To ensure safe landing between the theoretical courses taken at the university and the practice in the postgraduate phase. **(Guidelines L4 , L5 , I1 , I2 , I4)**
- To provide students with the minimum necessary years of BIM experience at the time of their graduation. **(Guidelines L5 , I8)**
- To ensure a systematic understanding of the key aspects of the BIM system and its role within the architecture engineering and construction industry. **(Guidelines I4 , I6 , I7)**
- To supply the student with the basic managerial skills in the digital age. **(Guidelines L1 , L2 , I8)**

c) Implementation of Learning Outcomes

The purpose of the developed framework is to facilitate the implementation of BIM systems within the undergraduate curriculums. Each university's curriculum is unique in its structure, yet students are expected to attain the set learning outcomes prior to their graduation. In order to ensure a smooth and flexible curriculum update upon the adoption of BIM, this research suggests the addition of 3 subjects to be applicable within the consideration of the learning outcomes of any university. The new outcomes ensure the realignment of the learning process through instructional strategies with the needs of the industry, without any interference from the core academic content of the university.

The new learning outcomes to be added shall consider the 3 main parts of the BIM system as described below:

1. Technical: Understand the various tools of BIM and demonstrat high proficiency using the appropriate tool to generate the project requirements.
2. Practical: Demonstrate a systematic and practical understanding of the managerial role of BIM within the AEC industry.
3. Theoretical: Demonstrate a systematic understanding of the different roles and capabilities of BIM within the various project phases.

d) **Implementation Requirements**

- The various BIM theories should be introduced to the university professors in order to provide them with the adequate BIM understanding and enable them to support the students in BIM implementation. The focus here is not on the whole BIM system, but on acquiring the basic BIM knowledge and providing students with the learning content to be instructed to students in each course.
- It is highly advised to assign a BIM technical assistant at the faculty to support students in using the BIM tool fully in order to translate their ideas and concepts into designs and generate models, even if they are complex or organic. This insures that the students' creativity is not being constrained by any technological tool but rather being tackled and motivated to get the best ideas out of the students.
- It is crucial for students to get exposed to the professional industry, since there is a shift in the level of knowledge and tools used when progressing

from the third year to the fourth year of the architectural program. The university should provide students with opportunities to practice BIM in a real-working environment during their educational period, similar to other curriculums, such as medicine and dentistry. It is important for this module to be accredited and reinforced within curriculum through clear evaluation and assessment criteria. This ensures the student will attain both the educational and the professional experience by the graduation level. Therefore, their chances of employability increase in a short period of time upon graduation.

e) Implementation Criteria

The implementation of BIM within the curriculum can commence from the first year as explained below, or can be managed to be integrated within the existing courses and syllabus. The decision to move on with each option is taken after the institution performs an analysis to mark its global level status of IM use within its educational curriculum. The analysis shall take into consideration the different capabilities of students along the five-year program.

f) BIM Implementation Framework

The chosen instructional design methodology for guiding the implementation of BIM framework follows the ADDIE model. The concept of this model is based on a hierarchical five-step structure that is built upon the structural completion of one another. Each of these five stages includes sub-stages as well. The completion of each stage gives an output to be reflected in the stage, after, which provides continuous feedback and improvement.

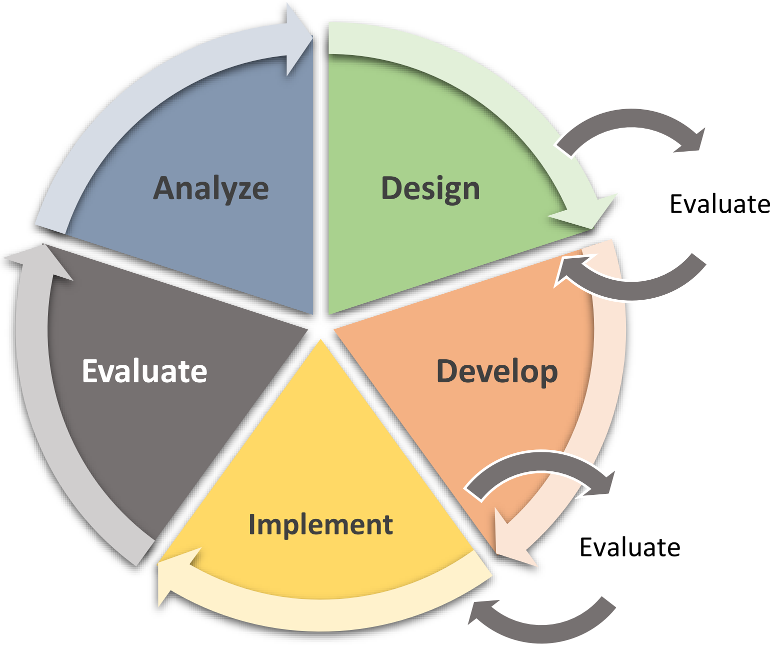


Figure 6-5 Framework structure

The following structured BIM educational framework presents the final output of this research and acts as a guideline for any institution that aims to implement BIM in its curriculum and is unsure of the starting point. The framework organizes the steps of implementation and highlights the expected outcome for each phase.

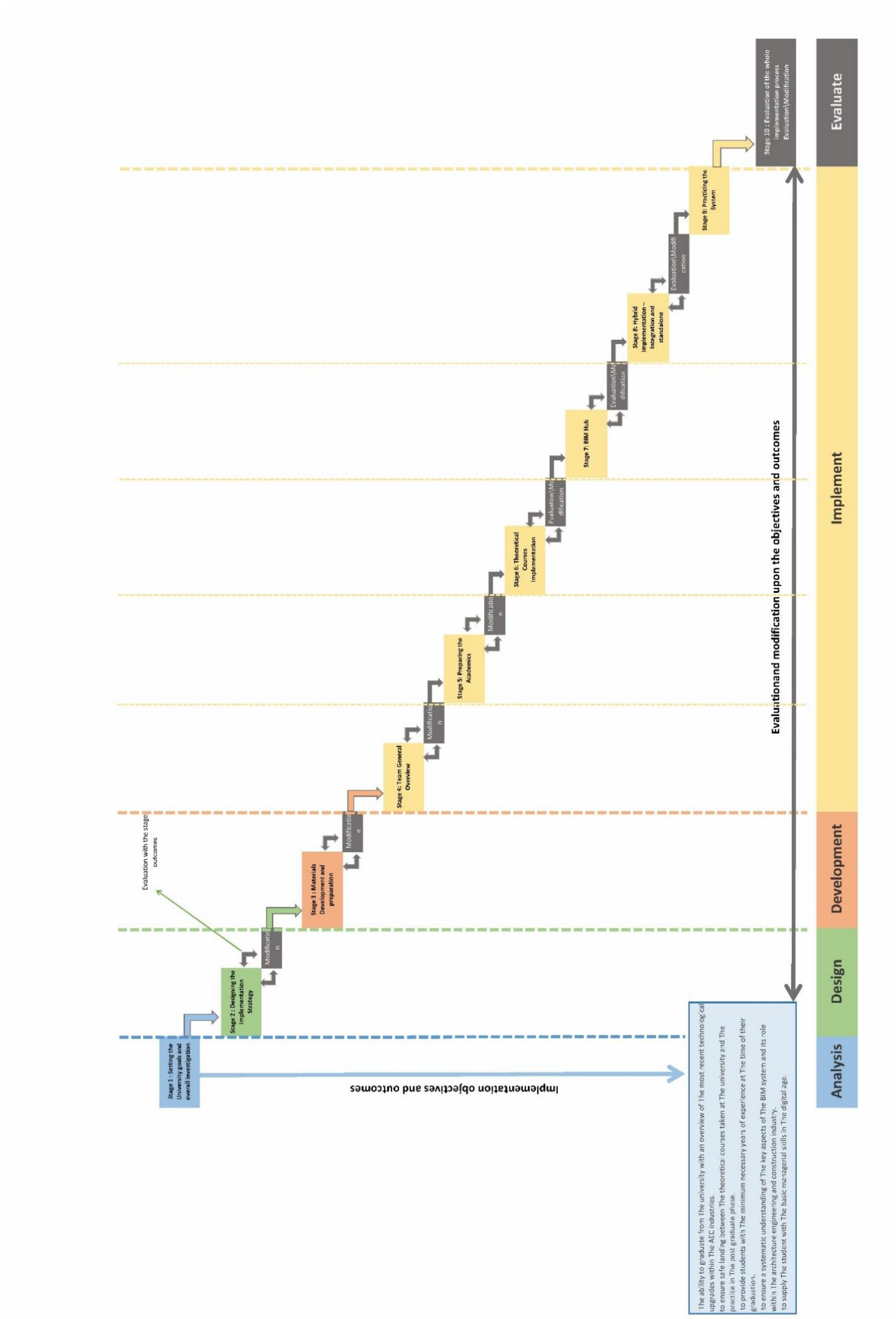


Figure 6-6 Developped framework diagram

Analysis Phase

Stage 1: Setting the University Goals and Overall Investigation

The first stage starts with the analysis of the current status and the setting of BIM-related goals the university aims to achieve from the implementation of the BIM educational framework. The university should analyze the gaps detected in the existing academic syllabus and identify the barriers which might hinder the BIM implementation process including, but not limited to: lack of BIM knowledge, lack of BIM skills, lack of technicians, etc. The result of this evaluation is the planning of the academic resources needed to fulfill the implementation process, such as assigned professors, supporting technicians, educational learning content, etc.

Next, the focus of the university is on professors and students, which are classified as the target audience. At this stage, the goal is to ensure that the program matches the skills and knowledge of the recipient audience from the professor, who should have the adequate knowledge and understanding of BIM to pass it on accurately to the student. The university should define what topics are already included in the educational syllabus to avoid duplication, and it should set the new BIM learning content to be instructed to students.

The university is then required to set the new learning objectives related to BIM implementation and what the target audience, represented by the students, are expected to achieve at the end of each semester; i.e., expected BIM knowledge level, suggested ways of communication, anticipated BIM skills, etc.

Stage Outcomes

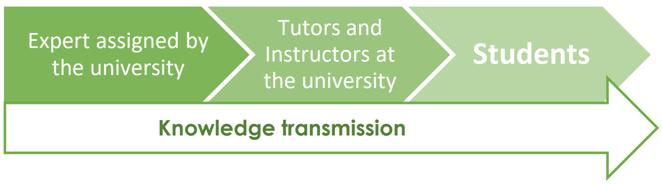
- Definition of new goals and learning outcomes to be achieved upon the implementation of the BIM educational framework.
- Identification of the BIM skills and competencies to be acquired by the target audience.

- Formation of full awareness of where the faculty stands within the BIM implementation in education.

Design Phase

Stage 2: Designing the Implementation Strategy

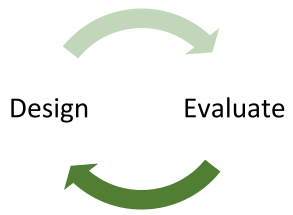
This stage ensures that every implemented step is logical, systematic and within its order.



Following the identification of the learning objectives in the earlier step, experts assigned by the university are required to plan the new BIM coursework with a focus on few aspects. For instance, the learning content, lesson plan, learning materials, tools for delivering the information, evaluation, assessment criteria, and feedback tools in the implementation phase that deals with professors in the first step and then with students in the second step.

The university shall set the strategy that involves the gradual implementation process of BIM within its program, which shall be discussed in the upcoming stage. For instance, the strategy shall answer questions including, but not limited to:

- How will BIM be implemented?
- Shall BIM implementation occur at all stages at once?
- What is the required time frame to achieve full implementation?
- What is the required budget to fulfill the implementation requirements?



The developed strategy should be discussed with professors and BIM experts responsible for testing and discussing the designed plan within the faculty, prior to the full implementation process. After that, professors and BIM experts should evaluate the overall idea and amend what should be enhanced.

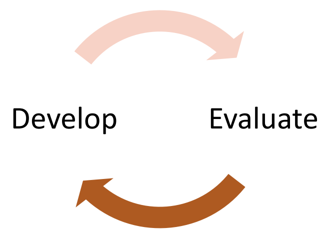
Stage Outcomes

- Formation of a clear instructional strategy which trains professors by BIM experts assigned by the university.
- Formation of a clear training strategy to train students by the certified academia from the university.
- Setup of a BIM implementation and monitoring plan divided into phases.

Developing Phase

Stage 3: Materials Development and Preparation

The earlier two stages of analysis and design focus on brainstorming and planning activities. The third stage of development puts the previous work in its detailed form. At this stage, BIM professors and professionals update the syllabus and develop the learning content, supported with presentations, real-life examples, illustrations, etc., to reach the target goal set from the implementation. This shall ensure a flexible and easy transmission of BIM information to the students.



At the end of this phase, it is essential to acquire feedback from discussions or conducted pilot tests which shall identify areas that need further improvement prior to the full implementation process. The steps follow a cycle of: develop - evaluate – develop.

The formerly prepared implementation plan is now ready to set its content in action to be utilized by two categories of learners: the professors and the students.

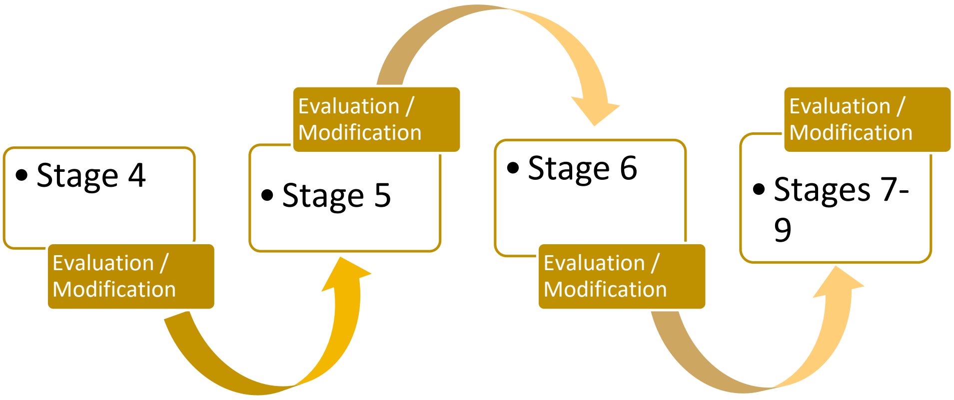
Stage Outcomes

- Development of the BIM learning content and syllabus that is understandable and implementable by different disciplines
- A developed coursework which ensures the achievement of the faculty's set objectives.

Implementation Phase

Evaluation Process for the Upcoming Stages 4-5-6-7-8-9

The process of evaluation acts as a control gate upon the completion of each stage and prior to moving to the following stage. Evaluating the outcomes of each stage will provide the faculty with the necessary feedback on the recorded results, which are expected to meet the objectives of the corresponding phase. The importance of this checkpoint relies in ensuring the fulfillment of the targeted goals and avoiding the accumulation of misunderstandings or errors that may pass from one stage to another.

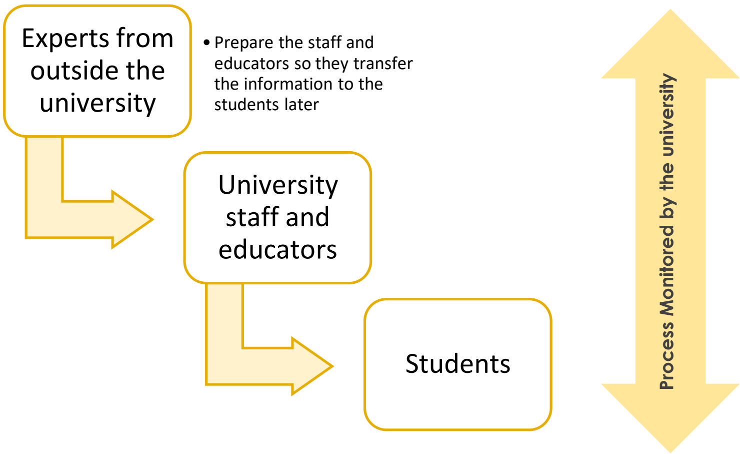


The structure of this phase is built on the dependency of each stage on the following one, where each stage acts as a pre-requisite to the stage after. The process of evaluating each stage can be performed using different methods: feedback obtained from group discussions, knowledge assessment through oral or written examinations, reports, questioning, etc.

Stage 4: Team General Overview

The implementation stage involves the continuous update and modification of the curriculum program to ensure that positive results and maximum efficiency are attained.

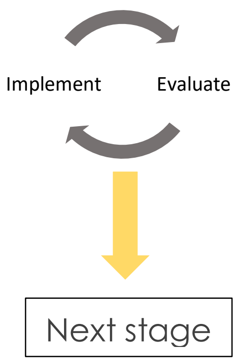
At this level, the university shall start with BIM introduction to the instructors through seminars, discussions, presentations, and workshops performed by external BIM experts if needed. The primary aim of stage 4 is to provide academic professors with the necessary information to build an adequate understanding of the BIM system. The attained level of BIM knowledge shall ensure that instructors will be able to support students in the learning of BIM and respond to their questions.



The delivered lectures shall inform the academia about:

- BIM definitions and its importance
- The several capabilities of BIM within the professional construction industry and the educational sectors
- The different tools and uses of BIM
- The overall situation of BIM and the current status of their faculty in comparison to the other architecture faculties in the country
- A general overview on the university's developed plan for BIM implementation

The importance of this sub-stage relies in engaging academics with the developed BIM implementation plan and familiarizing them with the new BIM content, which shall ensure a seamless and integrated mode of delivery to the students in the upcoming stages.



Evaluation tools:

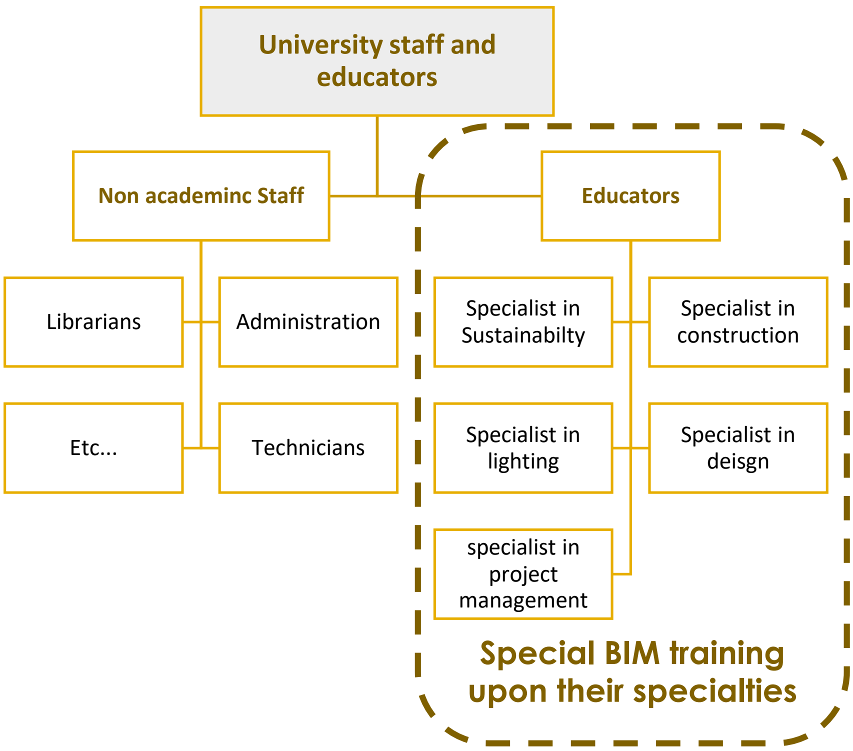
- Group discussions
- Questions and answers

Stage Outcomes

- Demonstration of an adequate understanding for the general definitions of BIM.
- Presentation of an understanding related to the faculty's BIM implementation plan.
- Illustration of a sufficient understanding for the role of each tutor in the BIM implementation process.

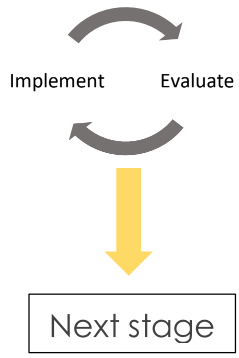
Stage 5: Preparing the Academics

The previous stage involved the training of the instructors from a general approach aiming to provide them with the basic BIM knowledge. This stage involves delving deep into the details of BIM knowledge and skills based on the instructor's specialty and teaching domain. The process of training instructors on BIM within their field of expertise ensures that tutors are capable of educating students BIM within their assigned coursework in a clear and understandable process.



The specialized BIM training to be instructed to the tutors should cover the BIM tools and learning material that the tutor will use in the upcoming application stage with students. Moreover, the acquired BIM knowledge and tools will be helpful in the BIM hub; to be discussed later.

It is favorable to reinforce the special BIM training for the educators with workshops that involve real-life examples and applications, in order to ensure the adequate understanding of BIM system and its uses within their respective coursework content.



Evaluation tools:

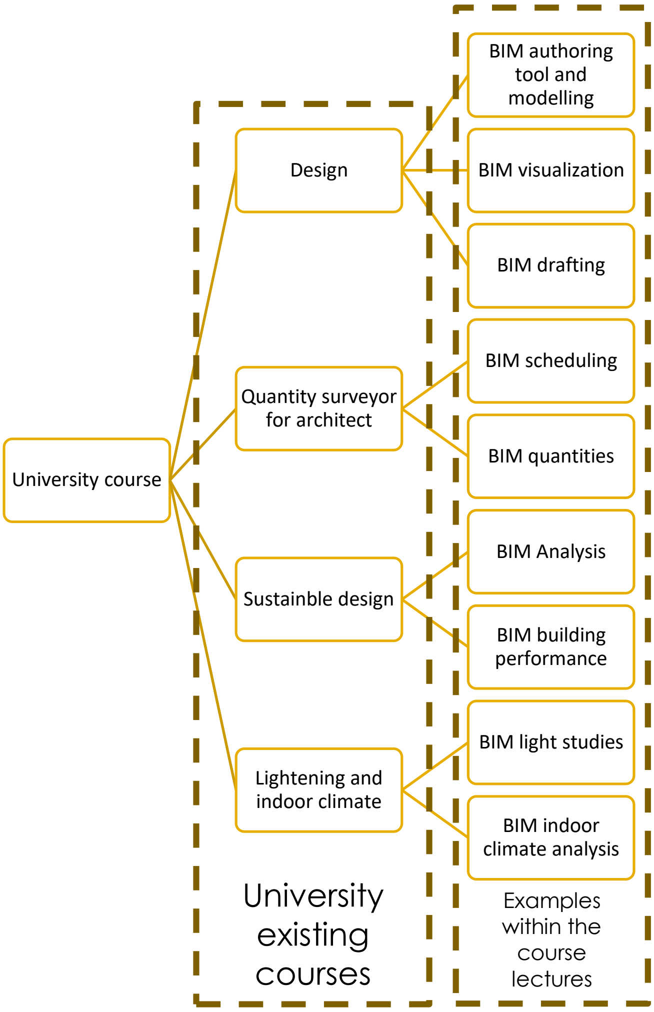
- Group discussion
- Question and answers

Stage Outcomes

- Demonstration of an adequate understanding of BIM use within the course and field of specialty by the assigned tutor.
- Reflection of understanding regarding BIM awareness and its general use in other disciplines.

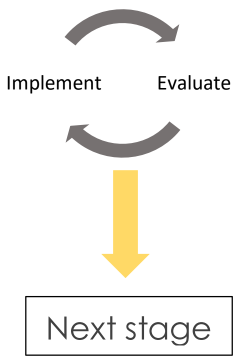
Stage 6: Theoretical Courses Implementation

At this stage, academia has already acquired the needed BIM knowledge and tools to commence the process of implementation with students within their coursework using different competencies.



The first step in implementing BIM and delivering the information to students by professors involves the introduction of BIM theoretically within their coursework content. The aim is to provide students with a general idea of the BIM system and how it works without going into details. It is important for tutors to support their theoretical content with real-life examples about the application of BIM in different scenarios. The suggested delivery mode at this stage is the presentation slides which could be kept for students as a reference.

For some courses, the implementation of BIM occurs from a theoretical aspect only. For instance, the specification and quantities course may not support the application of BIM in the extraction of quantities and costing, but may be limited to the theoretical aspect of BIM within this course.



Evaluation tools:

- Group discussion
- Question and answers

<u>Stage Outcomes</u>

- Reflection of a conceptual understanding of BIM system within the architectural and engineering disciplines by students.

Stage 7: BIM Hub

The implementation of the new BIM-oriented work plan, delivered by the educators to the students, is expected to motivate students and trigger their curiosity to learn more about BIM through self-effort.

The start out of a BIM hub by the university or a network of universities for learning support shall achieve this purpose. The hub will provide more information for students who need help in developing their skills to attain more competencies in BIM. Moreover, the BIM hub shall offer solutions which ensure that the creative ideas of students are not limited to issues that might arise during their practice in BIM and allow them to develop their complex design ideas using different BIM software. Also, the BIM hub shall support students in their understanding of the BIM system through gathering information and reinforcing the communication and collaborative working between different BIM users.

Senior levels in the undergraduate program may require an on-campus support, by a BIM technician, to help them in modelling complex forms in the conceptual phase of the project and aid them in developing high technical details in further stages.

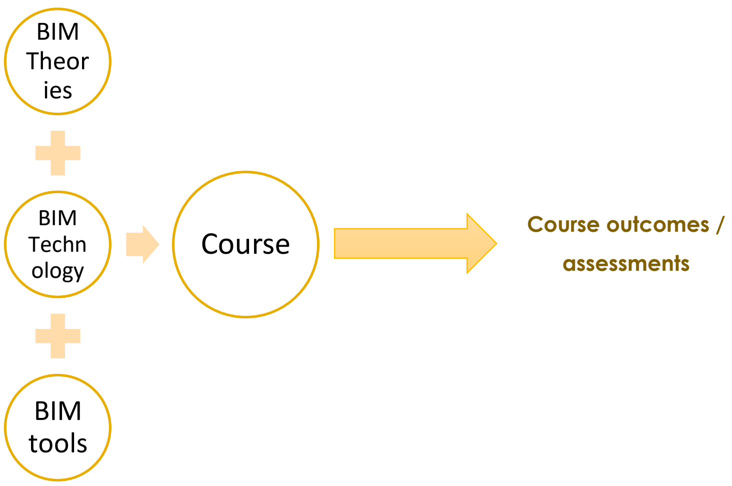
Stage Outcomes

- Better communication and enhanced collaborative working between different hub users; professors and students
- Collaboration between BIM technicians and students
- Fulfilment of the university requirements and objectives related to BIM technical aspects

Stage 8: Hybrid Implementation – Integration and Standalone

The full integration of BIM within the coursework is not fulfilled until the output received from students reflects their knowledge and understanding of BIM within their submitted work to be later assessed, which is represented in reports and project submissions.

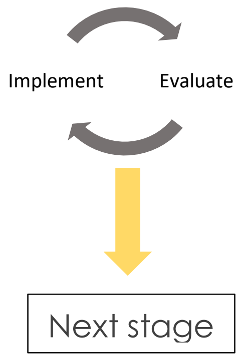
The upgrade performed by the professors on the learning coursework content and learning objectives is expected to fulfill the expectations of BIM integration. Through the application process, the role of the instructor is to create the opportunity for the student to work within the BIM system from the theoretical and practical perspectives. This is achieved through assigning projects and performing assessments that include BIM knowledge and understanding within their evaluation criteria.



Faculty might find it suitable to add supporting standalone courses; as mentioned in the table in the following section; in order to reinforce BIM implementation. The standalone modules work in parallel with other modules to support the full understanding and awareness of BIM, especially in the theoretical and technical aspects of BIM.

Moreover, the standalone courses reinforce the collaborative working process of the BIM system. For instance, the university can allocate a virtual project for a group of engineers from different disciplines to work on within a course.

With the instructors being fully aware of BIM at this stage, they shall request from students to reflect their BIM capabilities in coursework submission. The initially set BIM learning objectives are now to be tested and evaluated to see whether it was successfully delivered and transmitted to the students.



Evaluation tools:

- End of the course reports
- Class discussions
- Course assessments

Stage Outcomes

- Reflection on the understanding of BIM system and its use within several courses and disciplines.

Stage 9: Practicing the System

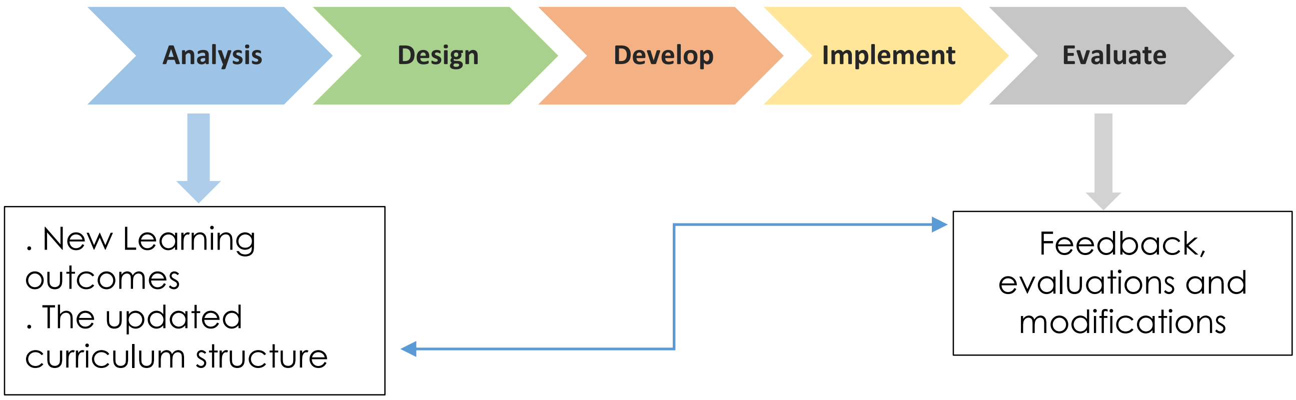
The final sub-stage of the implementation stage involves the exposure of students to real-life working scenarios for a deeper level of BIM understanding that is represented in professional applications. This is achieved through the university's completion of accredited summer internship programs, which require students to practice at professional companies that adopt BIM within its working scheme. This aims at ensuring students gain professional experience in BIM and increasing their BIM awareness rather than focusing on a specific BIM specialty. The goal is to expose the student to a working environment that allows them to work as part of a collaborative team, communicate with different disciplines, deal with problems, and propose solutions. This stage is furtherly explained in the table found in the upcoming section 5.2.4.

Evaluation Phase

The final stage, denoted as stage 10, is one of the most critical stages in the whole process of BIM implementation. After the evaluation performed on all the sub-stages, the final evaluation of the whole implemented BIM educational framework takes place at this level.

In this phase, the university will be testing the full implementation of the BIM educational framework within the curriculum including the comparison of the final outcomes to the BIM objectives and goals proposed in the first phase of the implementation.

Upon the completion of the last assessment, final feedback is collected for the purpose of continuously improving the process until the university attains the desired BIM learning outcomes, which reflect the successful implementation of the BIM educational framework.



6.2.3. Full Implementation within the Curriculum

The previously discussed ADDIE model for the BIM educational framework implementation is gradually applied to the five-year undergraduate architecture curriculum, as explained below, to achieve full implementation. This section provides what a full plan can attain after a successful BIM implementation in the Lebanese curriculum. The module used in this section in the common one between the Lebanese universities that provide architectural education.

The major advantage of the developed BIM educational framework is that it can be implemented selectively each year of the five-year program. However, without compromising the chance of senior levels missing the opportunity to get BIM education even if theoretically. In more details, the implementation of the framework is guaranteed to achieve full results if implementation occurs in the first year or even the second year, where by the year of the graduation students would have covered all BIM-related learning content. Results are still achieved, even if not fully, if BIM framework was implemented in the 3rd and 4th levels in the form of theories or standalone courses. This does not limit the privilege for students to gain BIM knowledge and understanding. Implementing BIM for students who are already in their graduating year is challenging and does not achieve the full outcomes when compared to the full BIM educational implementation plan framework. Yet, students can still have the opportunity to get the basic knowledge and understanding of BIM.

The curriculum below is based on the 5-year architectural curriculum in Lebanon taken from several universities; the order of the modules might change based on the university criteria and curriculum.

1st Year:

BIM Introduction: (Theory - Standalone)

BIM concepts and theories are given at this level through introductory modules, which compel students to **analyze** theories and case studies that have

adopted BIM and resulted in beneficial BIM learning outcomes. This module shall encourage the student to adopt this **new technology** without feeling the pressure of going into the whole system of BIM.

- Outcomes: **Demonstrate** an understanding of basic BIM knowledge and theories.

BIM Tool: (Theory - Standalone)

BIM is effectively used as an authoring tool when students learn how to generate objects and draw using BIM tools, such as **Revit** and **Sketch-up** or when students perform analysis and gather data using BIM tools such as **Ecotect**.

Figure 6-7 BIM tool and software source: https://veincon.com/blog/why-do-architects-need-computational-bim-workflows

For this purpose, the presence of modules which support students in learning BIM tools are introduced. These modules provide the students with important insight into BIM capabilities and tools and build up a generic knowledge for its future use. Hence, students can choose the appropriate tool when needed.

- Outcomes: **Understanding** the various capabilities of BIM tool from a general view.

Design / Building Technology (Technology - Integrated)

At the level of the first year design module, students get to deal with shapes, geometries, and forms which can be represented using BIM tools to generate conceptual models and masses and this could be done using platforms, such as: **Fusion 360 or Sketch up.** This is highly effective when the design involves organic and parametric shapes.

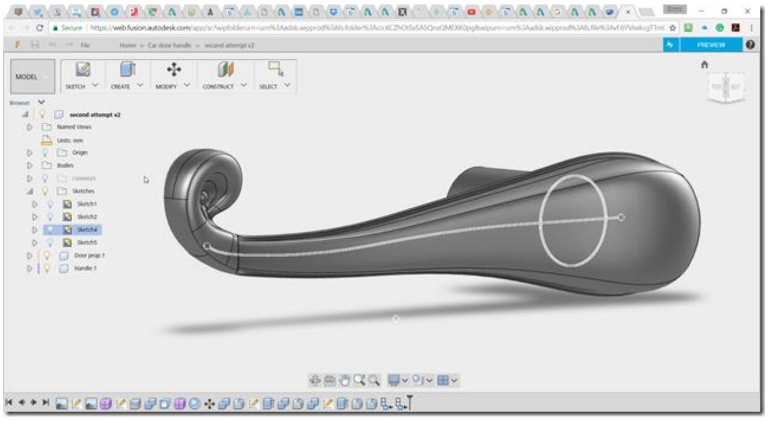


Figure 6-8 Door Handle design using fusion 360
https://autodesk.blogs.com/between_the_lines/2017/07/fusion-360-in-the-web-browser.html

Moreover, students could use BIM as a capturing tool to transform their handwork models to a digital model where they can edit and perform analysis easily.

Figure 6-9 Interior of Villa Ephrussi de Rothschild, 3d photogrammetry example Source : https://www.coroflot.com/chrisis/Photogrammetry-Architecture

At this phase, students get to work on an object scale level where they design various types of generic masses like conceptual models, windows, doors, furniture etc. This approach allows the introduction of BIM to students starting from a simple object scale.

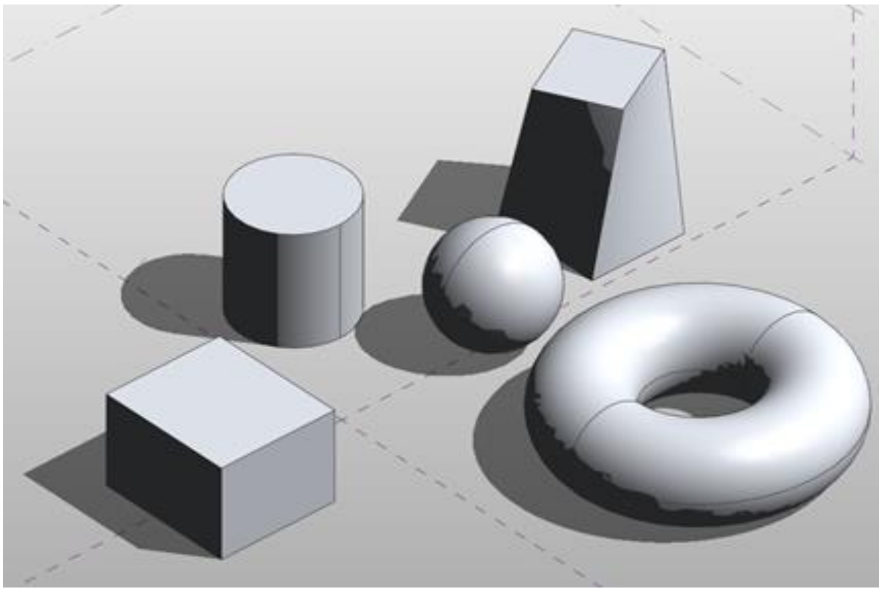


Figure 6-10 Using Revit conceptual model to generate primitive domestic shapes , source : http://autodesk-revit.blogspot.com/2010/09/back-to-basics-conceptual-masses-in.html

- Outcomes: **Create** and **generate** conceptual models representing the projects' components using easy modelling BIM platforms.

Site Visit: (Practice - Standalone)

The first level involves site visits where students acquire knowledge through observing executional work and report them to the university. Through this module, the student shall acquire the visual knowledge which enables him to co-relate the different components he experiences on site with what he learned at the university.

- Outcomes: **Demonstrate an adequate understanding** of different project components and objects and their respective representation within the BIM model environment.

2nd Year:

BIM Theories (Theory - Standalone)

One of the key goals of the theoretical courses is to introduce students to the basic definitions of BIM coordination capability between different disciplines.

- Outcomes: **Demonstrate an understanding** on the communicating and collaborative working achieved through BIM use.

Building Technology (Technology - Integrated)

Students have previously learned how to generate project components and customize them on an object scale. At this level, BIM scale is developed to involve the whole project scale.

By the second year, the design modules allow students to elaborate their project program on a full scale involving a complete set of coordinated drawings from plans, sections, and elevations represented through BIM. This is achieved through shifting from 2D manual tool to the digital BIM tool like **Revit** or **ArchiCAD,** where the student is capable of gathering, inserting, and extracting project data.

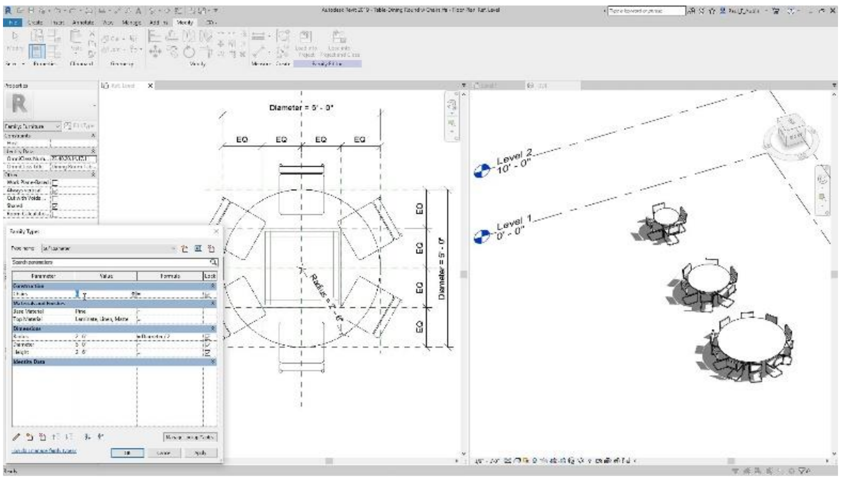


Figure 6-11 Modelling with Revit , data and parameters , Source: https://www.autodesk.com/products/revit/features

- ➢ <u>Outcomes</u>: **Demonstrate an understanding** on the transition from 2D CAD to the common data BIM environment.
- ➢ Reflect the ability to read and deal with data from the BIM information system.

Engineering (Structure -MEP) Courses for Architects (Technology - Integrated)

By the second year, students should have reached the minimum level of BIM knowledge. At this level, the courses are more advanced where tutors demonstrate the new BIM technology in architecture in an approach that serves the learning content of the taught coursework. This could be done through **YouTube** videos made by BIM vendors, Autodesk, BIM experts, or through live demonstration given by tutors who are aware of BIM software. For example, within the structure course the tutor can perform a live demonstrations on how to detail a structure using software like **Tekla** or provide students with visual learning material about the tool itself.

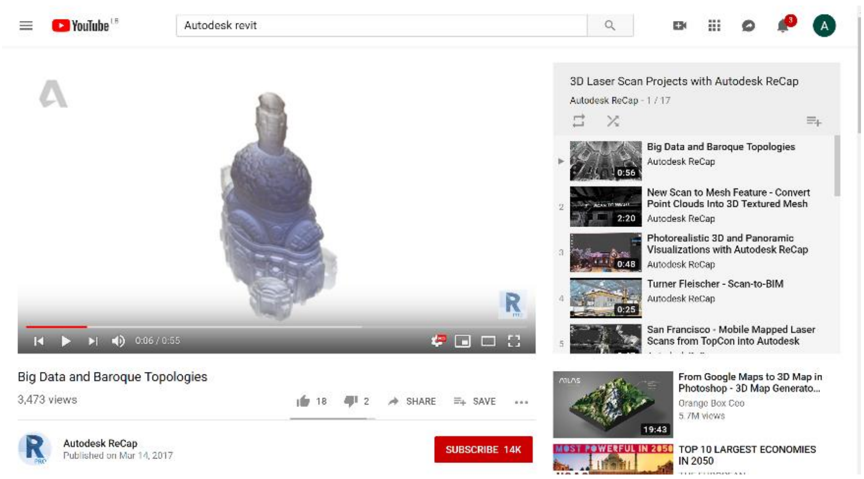


Figure 6-12 Big Data and Baroque Topologies Youtube Video example from Autodesk platforms. Source: https://www.youtube.com/watch?v=6_Peo5W5sKo&list=PLQOxJKble-75HI75fkBBocpgdPKTdOhVn

Through this approach, the student won't feel the pressure when it is time to shift from the theoretical aspect of BIM to the practical aspect, since they have already developed a preliminary idea about it.

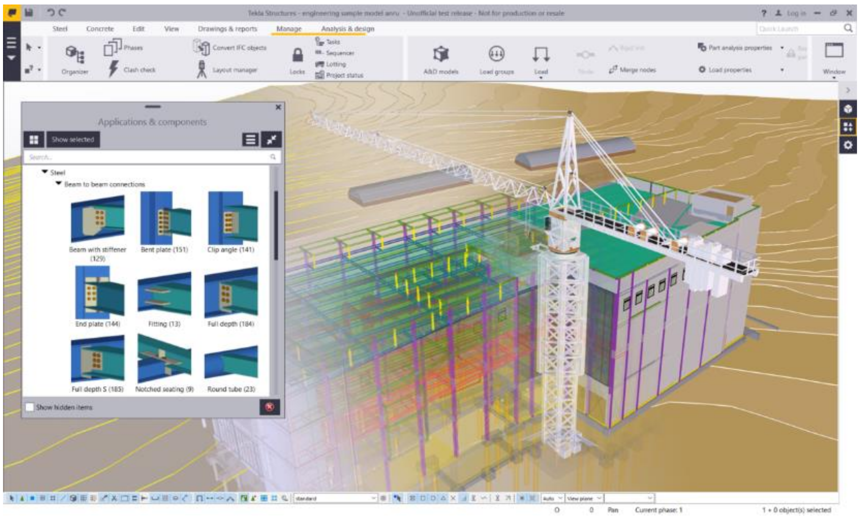


Figure 6-13 Tekla structural model source: https://www.tekla.com/products/tekla-model-sharing

- Outcomes: **Analyze and experience** the integration of BIM within engineering modules through the use of BIM tool in the outcomes delivered in the module.

BIM Tool Assistance / BIM HUB (Practice - Standalone)

At this level, students are aware of the various BIM tools and are able to differentiate between them. Students think in different ways, and their needs are different; the main purpose of the BIM hub is reflected at this point. The BIM hub acts as an assistance tool that helps the student reach their needs. BIM tool facilitates the visual presentation and the transformation to digital modelling and digitization. Therefore, it shall not act as a barrier for the student's creativity, but rather support students with solutions and aid them to overcome any technical issues they might encounter.

- Outcomes: **Develop the ability to** generate designs and models using specific BIM tools and platforms.

Environmental Sustainable Course (Technology - Integrated)

Students need to understand the rationale behind using the BIM tool in order to be motivated to learn it. It is important to highlight within the modules the different capabilities that BIM offers. This will enable students to understand the importance and uses of BIM tools in order to deliver better quality outputs in their work.

For instance, BIM has the capability to perform environmental analysis to the project which necessitates its incorporation within the environmental design courses in the form of **Revit,** for example, to simulate the building performance.

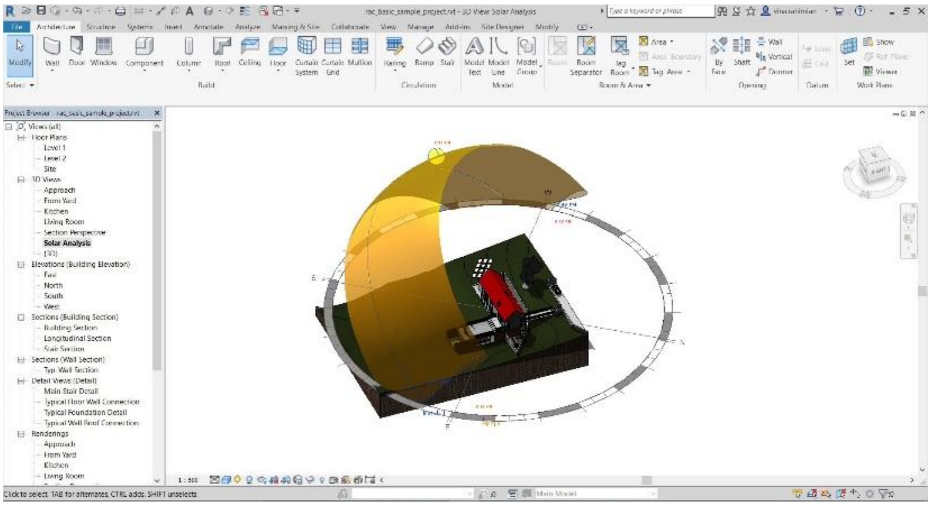


Figure 6-14 Using REVIT BIM tools to generate environmental analysis Source: https://blogs.autodesk.com/insight/facade-design-with-insight-webinar/

The importance of BIM in approaching sustainability is highlighted in theoretical courses through case studies of similar projects that adopted the same approach and achieved sustainable accreditation.

- Outcomes: **Demonstrate an understanding** on the role of BIM in promoting sustainability within projects.

Summer internship (Practice - Standalone)

To support the theory coursework taken during this stage, it is highly recommended students perform accredited summer internship programs at BIM-oriented companies. This performance offers them a wide exposure to other disciplines and how things actually work between the whole project team members. The internship program allows students to build a visual knowledge that supports them when they return to their third year of study.

Outcomes: **To demonstrate a BIM knowledge** related to the professional work in the industry across different disciplines.

3rd Year

Architectural Design / Execution Design / Interior Design (Technology - Integrated)

The typology and scale of the design projects are elevated this year. After the series of coursework and internships that were acquired in the previous years, the student should be capable at this year to fully develop his project within the context of the BIM system. The coordination between design and execution is visible in the representation of objects and details. Students should be able, at this level, to generate a complete project reinforced in visual presentation using the BIM analysis tool that adds value to the project.

- Outcomes: **Demonstrate the ability** to fully integrate BIM within the design project and generate a complete set of project drawings

Urban and Environmental Courses / Other Engineering Discipline Courses: (Technology - Integrated)

When BIM is integrated in different modules, students get to understand the importance of BIM in several aspects and get to know how it works. The exposure of students to BIM in different subjects is important to allow them to learn how to analyze and retrieve BIM data flexibly.

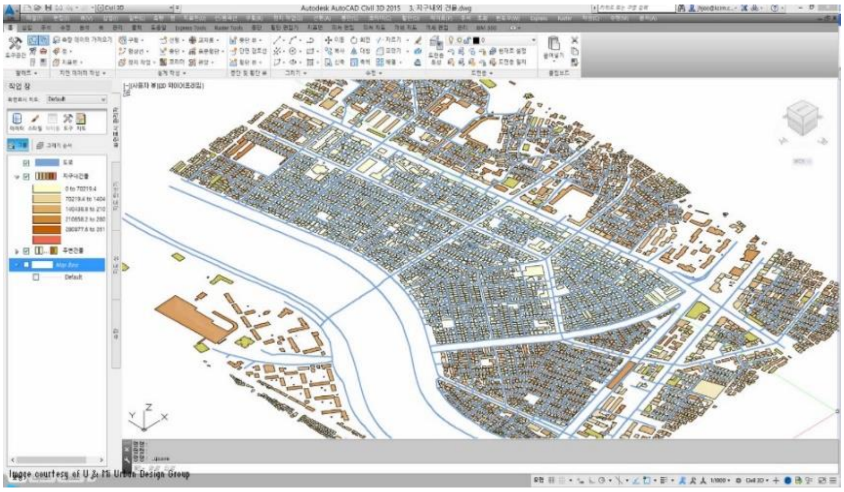


Figure 6-15 Urban Analysis Using BIM, Source: https://www.autodesk.com/solutions/bim/hub/u-mi-uses-bim-for-urban-planning-land-design

- Outcomes: **Develop the ability** to work within BIM space and perform analysis and manage data on a BIM shared model.

Accredited Internship Module: (Practice - Standalone)

At this stage, students are fully aware of the role of other disciplines in implementing their data on the building model. Students, moreover, get to experience and know the importance of communication and coordination between different teams of the project. This could be achieved through an accredited supporting module that serves to teach students about the professional experience or through theoretical standalone modules.

- Outcomes: **Experience** collaborative working and communication within BIM system.

4th Year:

Architectural Design Course / Execution Design: (Technology - Integrated)

At the level of the fourth year, theoretical courses are still important to attain a high level of understanding regarding the capabilities of BIM and the collaborative working environment in support of design courses. A great demonstration can be through assigning a single project group work between multi-disciplines, which enhances communication and improves collaboration similar to the experience gained in a professional internship.

- ➢ Outcomes: **Demonstrate the ability** to work, communicate, collaborate, and exchange BIM information with different disciplines.

Specifications and Quantities Course: (Technology - Integrated)

Students get to go into the production of details in the project through execution design courses and detailed design drawings in order to produce a complete project. At this point, the shift from the object scale to the project scale and its details is attained.

During this phase, students should be able to fully generate data from the shared model and thus achieve more BIM efficiency. For instance, the specification and quantities module shall require the use of BIM in the process of extracting the quantities from the BIM model using tools such as Revit software.

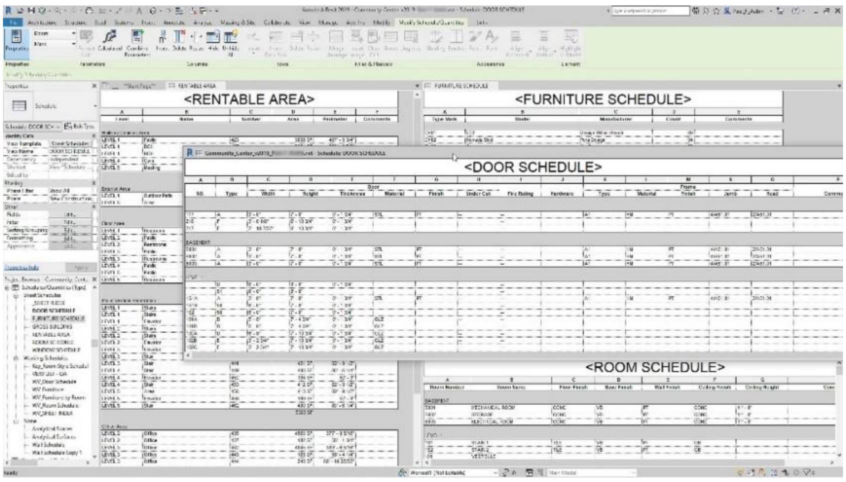


Figure 6-16 Generating Schedules Using Revit Source: https://www.autodesk.com/products/revit/features

- ➢ Outcomes: **Apply** the BIM system to produce project-detailed design and execution drawings. In addition, using BIM tool to extract information from the model.

Architectural Design Course: (Technology - Integrated)

A BIM technical support division is needed at this level, since students will be introduced to a more advanced BIM level that requires acquiring developed BIM skills and tools that are prerequisites to promote them to an advanced design level. With the support of the BIM technical assistant, students shall find it easier to generate organic forms or parametric designs using advanced tools, such as **Dynamo** and **Rhino**.

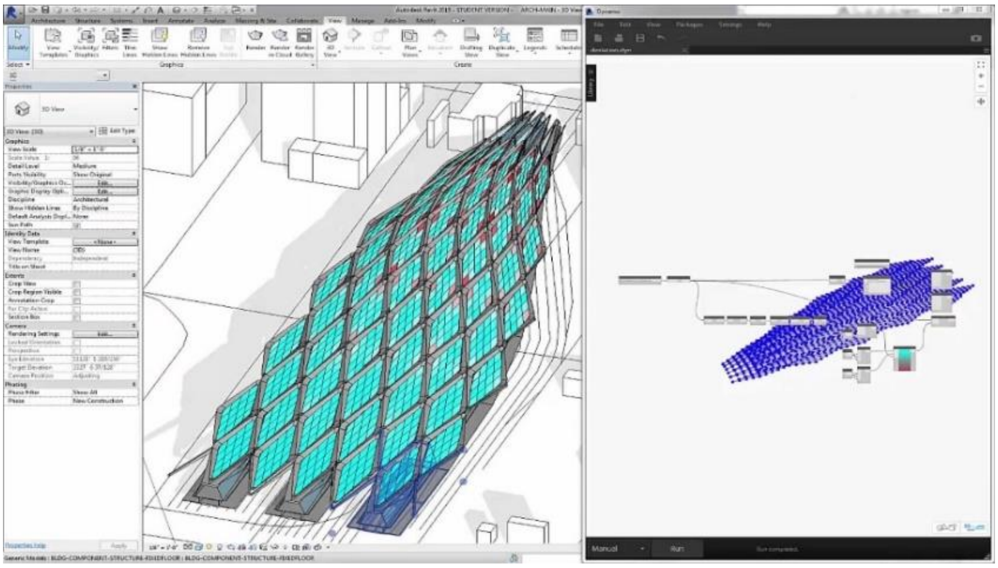


Figure 6-17 Manipulating Data Parameters Using Dynamo from Autodesk
(Source: https://www.revit.news/2015/08/dynamo-tutorials-part-iv-manipulating-data-parameters/)

- Outcomes: Acquire **advanced BIM tools** that enable students to develop complex ideas in support with a **BIM technical assistant.**

Advanced BIM Theory: (Theory - Standalone)

In the previous years, students gained some observations concerned with BIM as a management platform through the accredited professional internship module. The reflection of these observations is conveyed through discussions with students and the feedback obtained. The advanced BIM management module promotes students to a new level, which focuses on the managerial aspect of BIM mainly through performing cost estimation and schedule planning for a project's construction and operation.

- <u>Outcomes:</u> **Demonstrate an adequate understanding and knowledge** of **BIM management** through planning and estimating the cost of a project's lifecycle.

Accredited Internship Module: (Practice - Standalone)

To ensure a full understanding of the theoretical course given during fourth year level. Students are expected to complete another accredited internship module to emphasize their knowledge and reinforce their practical skills.

- <u>Outcomes:</u> **Demonstrate an ability** to work within a team and understand the various role of BIM inside a project.

5th Year: Graduation year for the 5-year program

Accredited Internship Module: (Practice - Standalone)

The output of the theoretical courses and professional internships are reflected in the final fifth year. Students are expected to engage in an accredited internship module and submit reports that reflect their BIM knowledge, professional experience, and achieved learning outcomes.

- <u>Outcome</u>: **Demonstrate the ability** to work within the practical industry BIM experience.

Project Management / Building Regulation and Professional Practice (Theory - Standalone)

In the final year, students are expected to submit reports in core modules, such as project management, building regulations, and professional practice. These reports should reflect the level of BIM knowledge, understanding, and maturity that the student has achieved within the BIM system.

- <u>Outcomes</u>: Understand the **added value** which BIM system offers to a project's lifecycle.

Graduation Project

The final output of the 5-year program is the graduation project. Students are expected to submit their graduation project in the design and thesis modules with a full reflection on the BIM competencies, which they have acquired along the past years.

- Outcomes: **Demonstrate the ability** to fully integrate the BIM system within any engineering project.

6.3. Summary

The core outcome of this research was presented in this chapter in the form of a developed BIM educational framework for implementation in undergraduate architectural curriculums in Lebanon. The findings of the literature review together with the findings of the quantitative and qualitative data collection structured the draft framework. The development of the BIM educational framework utilized the different aspects of BIM in theory, tool, and practice on three ascending scales: object, project and detail. The developed BIM educational framework was initiated along with specifying the aim, objectives, expected learning outcomes, and requirements. The BIM educational framework discussed the selective or gradual implementation of BIM in the undergraduate architectural curriculum of the 5-year program, based on the categorization of three stages of implementation which offer more flexibility. The first stage is concerned with implementing BIM within an existing course. The second stage introduces BIM as a standalone course and the final stage involves the introduction of new BIM modules. The three stages take into consideration the theoretical, technological, and practical aspects of BIM.

Chapter 7 **FRAMEWORK VALIDATION**

This chapter aims at validating the developed framework of the previous chapter. The first part includes interviews with professionals in order to testify to their understanding of the developed framework and gather feedback and recommendations. Next, the researcher applies the developed framework to three scenario cases from Lebanese universities. Finally, publications performed as part of the validation process are discussed.

7.1. Introduction

The core objective of this research is to validate the proposed BIM educational framework implementation in undergraduate curriculums. The structure of the framework development was built on clarity and reliability from the early phases of this research up to the validation process.

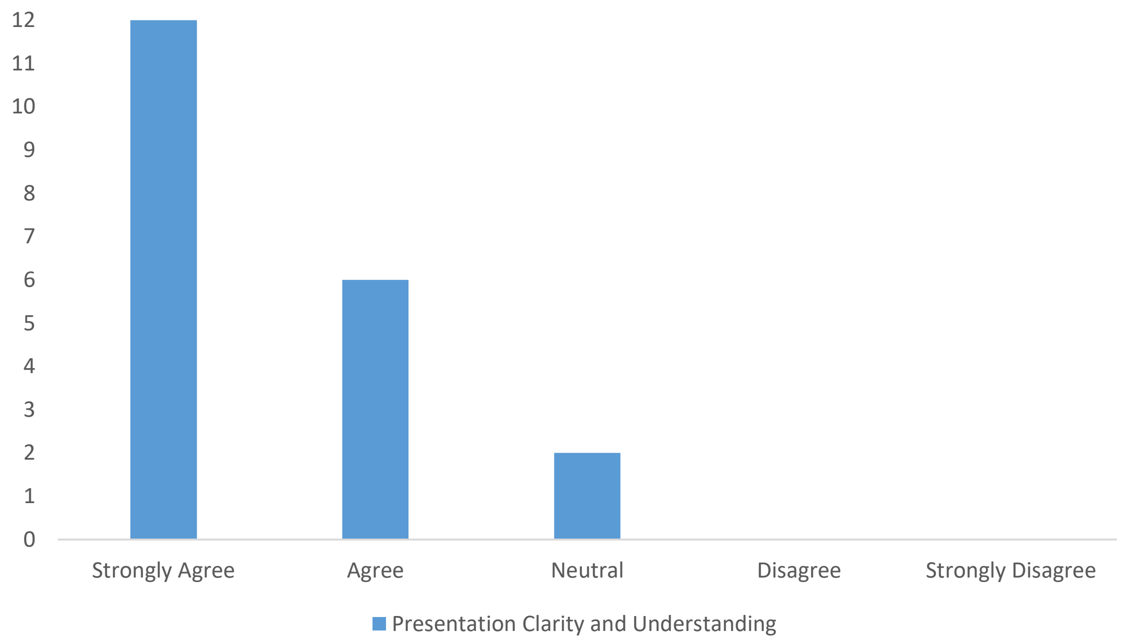
Summarizing the framework structure, the data collection started with the findings of the literature review of previous studies and surveys about the implementation of BIM in the professional and educational fields. Next, the research process went into further investigation on the status and understanding of BIM in the Lebanese architectural curriculum through a number of semi-structured interviews with students, educators, and practitioners. The outcomes were all translated to present a guided framework ready for implementation.

The reliability of this research relies in validating that the developed framework is practical and applicable. For this purpose, this chapter examines a series of interviews and application trials to test the effectiveness of the framework and the kind of responses from end users. Hence, the process of validating the developed framework consists of two sections. The first section of the framework validation is focused on a set of semi-structured interviews with professionals in the architectural education, who have a great BIM insight in order to testify the clarity and potential acceptance of the framework and gather some feedback from the end users.

7.1.1.

7.1.1. Interview Findings

What do you think about the clarity of the presentation in terms of structure and understanding?



12 participants strongly agreed that they found the presentation material easy to understand through the well-structured approach in explaining the framework. 6 participants recorded their strong confirmation and 2 participants recorded a neutral impression. Discussion took place either at the beginning or end of the presentation. Some participants were interested in having a hardcopy of the report in order to further expand their readings within the topic. The main highlights of the responses were: Int01 said

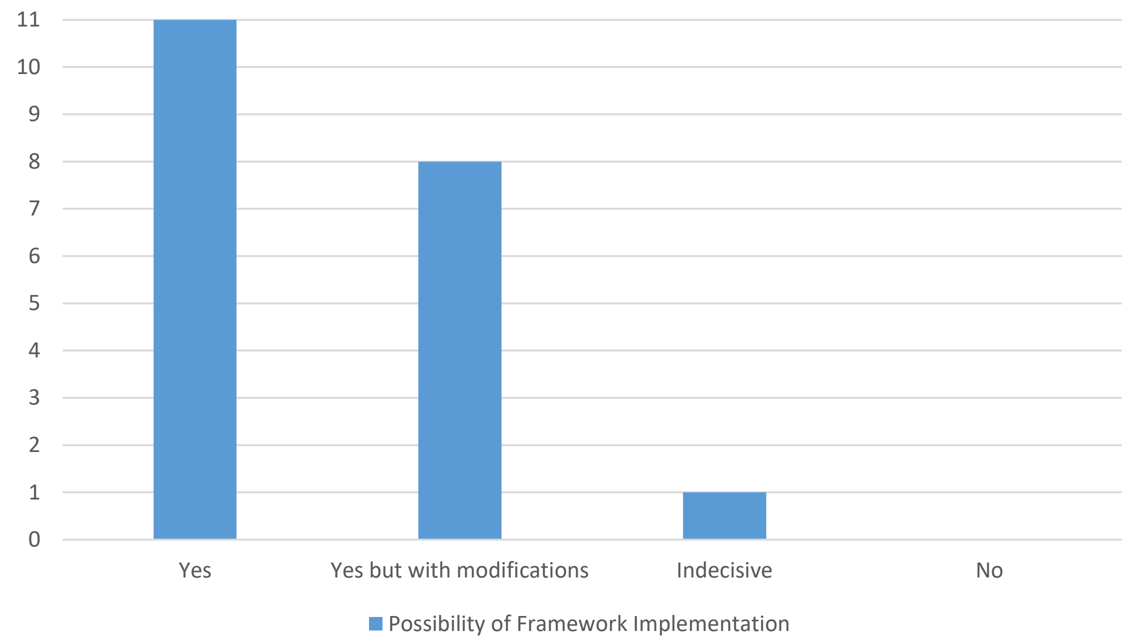
"I think I understood exactly what you are trying to do".

Similarly, Int 11 expressed

"The structure is clear and straight to the point".

Int 08 has expressed his interest in performing further interviews and discussions via emails or face to face, if applicable, during the researcher's UK visit.

Would you attempt to implement the framework within the curriculum?



When asked about the possibility of implementing the framework in the existing curriculum, where the professional teaches, Int01 thought that the framework doesn't imply massive changes to the existing curriculum. Yet, she claimed that it depends on the ground conditions.

> *"Because it depends on the context in which you are integrating BIM into".*

This response was recorded as indecisive. 8 of the participants assured that they would implement the framework if minor modifications were performed, in order to offer more flexibility. For instance, Int06 said that she would be happy to incorporate the framework into her own program if a demonstration on how the framework meets the RIBA targets was performed. Int11 suggests adding more flexibility within the framework implementation allowing some content joggling across the years of the program study. 11 Interviewers expressed full support in implementing the framework. Int06 thinks that the framework "*could be useful because the knowledge acquired through the modules could be explicit*". From the strong supporters were Int04, who considers

"The structure of integration in a gradual manner is adequate".

Also, Int15 thinks that the framework is

"Flexible, adaptive in its nature, and promising".

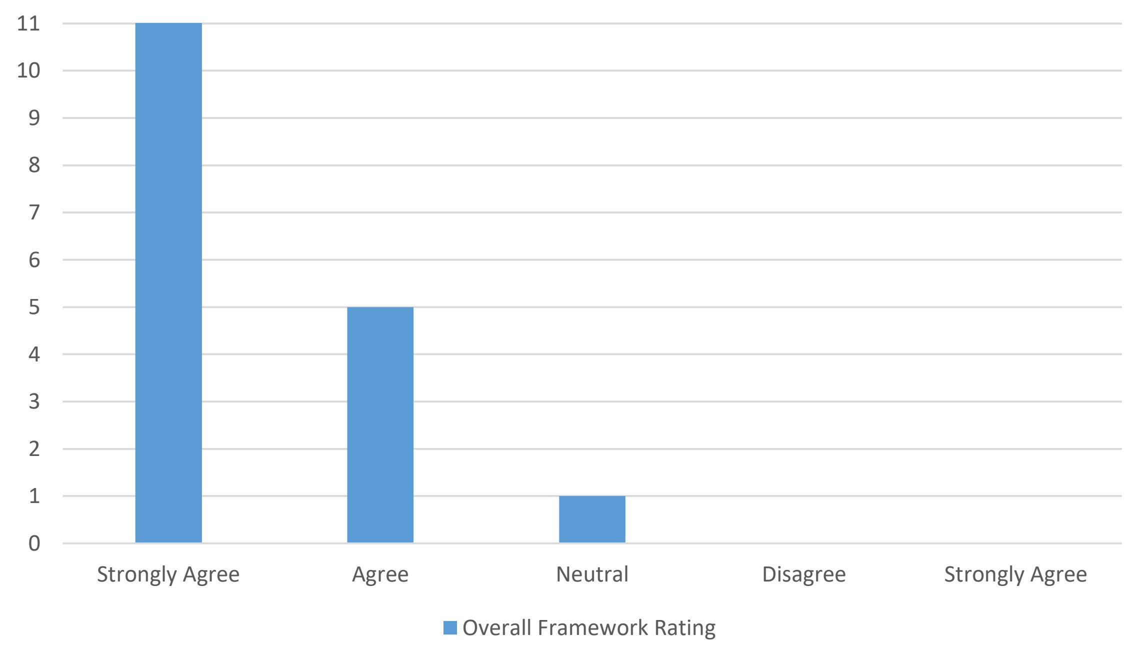
Similarly, Int17 said

"I believe we are in the middle of a great positive change in the Lebanese architectural curriculums"

And Int12 said

"This is exactly what our industry needs".

Do you agree with the overall framework?



14 out of 20 participants strongly agree with the overall framework, where Int04 thinks that that:

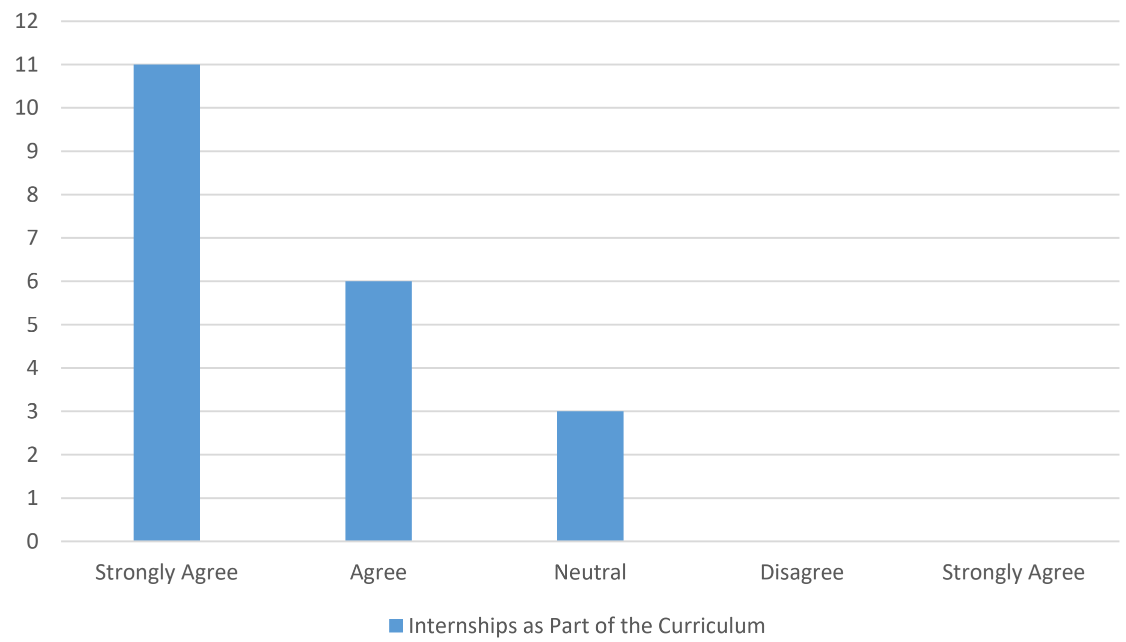
"The attempt to integrate BIM within the curriculum is useful and it shall be a successful one".

Int07 has expressed that the researcher has "a thorough framework" and that he "understood the subject and what has to be done". From his past experience, Int08 strongly agrees on the overall framework, since he has seen the problem of not having a practical experience when he was a student and has experienced it as a professional. 5 out of 20 participants confirmed their acceptance to the presented framework. For example, Int17 commented with

"I think it is a serious attempt for real change since a long time".

Overall, the participants were satisfied with the framework, leaving one participant's focus on BIM comments rather than giving a decisive opinion of agreement or disagreement.

Do you agree with the idea of implementing practice / internships as part of the curriculum assessment?



11 out of 20 participants strongly support the idea of having an accredited internship in the curriculum. Int03 believes that when students undergo on-site training, they realize the importance of BIM and how much it eases things up. Int03 thinks that

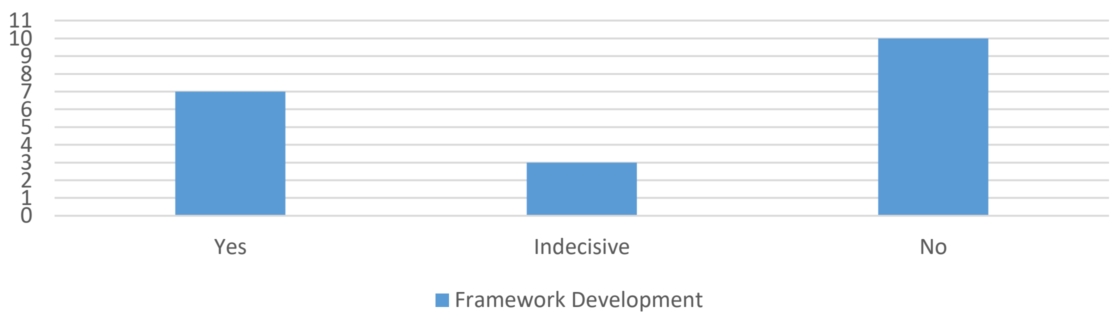
"the concept should be included now when introducing BIM within the curriculum through assigning a period of one preparatory summer semester or one full fall semester at the beginning of the curriculum".

Int04, Int12, 14 & 17 suggest that the training occurs every summer term but in a different discipline every time in order to allow the student to have various exposure and experience. The experience of Int06 confirms that students learn BIM when they apply it and learn the theories. Int06 thinks that

"The accredited internship makes sense".

Int09 strongly supports the idea of practicing BIM during the years of architectural education, since it facilitates the learning process for the student and widens the image of exposure to on-site occurrences. 6 out of 20 participants expressed their acceptance of the accredited internship idea. Int07 thinks that *"it is a tricky one, but yes, you need to include it"*. In his opinion, he thinks that if it is going to be accredited, then it needs to be assessed. He suggests that the university needs to work on ensuring internship opportunities for students if it is to be graded. Int08 suggests referring to the RIBA guidelines and books about internships and what students should be expecting and what professionals should be thinking about. Finally, 3 out of 20 participants were indecisive about the idea of the accredited internship, scoring neutral feedback.

Do you think that the framework needs further development?



7 out of 20 participants suggested some additions to the framework development. They basically agree with the whole framework, but based on their own experience and perspective, they see that these updates can enhance the suggested framework. For instance, In01 wants to break down learning outcomes and define them in a more specific manner. In03 suggests that at the level of the fourth year, a professional can explain the process of using BIM for a project from A to Z and afterwards allow students to replicate the same building before applying the whole system of BIM on his own graduation project. Also, Int04 suggests that 35% of the grade of the graduation project to be assessed is based on the use of BIM features within the project. Int07 & Int11 suggest adding some flexibility to allow the implementation of the framework by prioritizing the modules to be integrated if they are not to be implemented all at one. Int06 believes that the researcher has clearly stated what is needed for the implementation of the framework. Yet, he thinks that the "why" aspect needs to be added. He tackles the question of

"What would a graduate of architecture achieve in each year and how do you vision him being different from other architectural graduates now?"

As for int08, he suggests breaking down BIM practice as a first step into small scale tasks and post it on the learning hub to allow students to work remotely on an object scale. 3 out of 20 interviewees were indecisive about the question, leaving 10 out of 20 participants have no suggestions for the framework and generally seeing the presented framework as satisfactory.

7.1.2. Summary and Recommendations

As the majority of the interviewers showed support and encouragement for the developed framework, below is a quick highlight on the major comments to take into consideration while implementing BIM.

- It is important to maintain flexibility throughout the implementation of BIM in order to encourage different curriculums to adopt BIM without major challenges. Suggestions were to break down the steps of implementation to achieve a gradual adaptation from early to senior levels.
- Focus was then given to the breaking down of the learning outcomes. The introduction of BIM into the existing curriculum shall imply an update on the current learning outcomes in order to involve BIM-related ones, which shall be linked to assessments related to students' BIM skills and understanding.
- Since most existing curriculums lack the programs of summer internships that are BIM oriented, support was given to include these summer programs repetitively where students get to experience different BIM-related fields.

7.2. Validation Scenarios

One must bear in mind that the recommendations generated earlier from the interviews along the research period and the analysis of the curriculums which have identified gaps and opportunities, an implementation exercise was performed on three Lebanese undergraduate curriculums.

To further validate the process of scenario implementation, one-on-one coordination with 6 professional educators took place, 2 from each university, who have deep insight into the curriculum structure of their faculties and have provided their continuous feedback on the implementation strategy. The implementation took the original curriculum structure which details the modules taken every semester, in addition to the learning outcomes of the whole curriculum. As supported in the appendix, implementation involves modifications and additions to these curriculums. The way of implementation is not consistent iacross all three universities, but rather reflects flexibility on the existing modules, structure, and topics.

Generally, the process of implementation involves the design studio courses for BIM application; computer graphics for BIM tool learning; environmental and urban courses for BIM analysis, and professional practice modules for BIM practice, where curriculums tend to be more flexible. BIM management related courses are introduced within the specifications and quantities coursework or as a single elective course.

7.2.1. Case 1

First Year:

BIM is introduced in its concepts from the first semester of the first year within the module of "Introduction to Engineering and Architecture". The course description was updated to include highlighting the benefits of BIM use and promote its multi-disciplinary use. It is suggested, in the spring semester of year 1, to replace the module "Drawing II" with the "Digital Tools" module, which already exists in the fall semester of year 3. The course description is thus updated to involve BIM in the form of REVIT. The reason for this substitution is that students are believed to have gained the basics of manual drawing skills in the "Drawing I" module in the fall semester of year 1. Therefore, the priority in the spring semester is to introduce digital tools including BIM at an early stage rather than on the level of the 3rd year. Previously, digital software that were originally taught in the "Drawing II" module are now introduced as a separate elective course, such as InDesign, Photoshop, 3Dmax.. Since the curriculum already includes Surveying Regional Architectural 2D-3D module in its structure, the content was updated to involve the use of REVIT for 3D representation of the coursework.

Second Year:

The "Architecture Design I & II" modules in the fall and spring semesters of the second year suggests the use of REVIT in their course work, where students have acquired the skills to represent their projects using BIM, especially during the conceptual and urban 3D representations.

Third Year:

The “Architecture Design IV” in the fall semester suggests the use of Revit for the purposes of presentation, analysis, and modelling. Also, the modules “Environment I – Climate Response” & “Environment II – Building Systems” could make use of BIM in performing environmental analysis using REVIT.

Fourth Year:

The representation in the “Architecture Design V“ and “Vertical Design Studio II” modules, recommends the use of REVIT as a primary tool in generating outputs for projects submissions. The professional practice modules, as part of the spring and summer semesters, are advised to specify BIM as a core requirement in the professional training in order to build up some variety in the areas of BIM expertise.

Fifth Year

By the year of graduation, the modules of “Design Thesis I & II” shall have required by then the submission of the graduation project using REVIT model and have presented their building performance simulation results within their project.

New Elective

It is furthermore recommended to add a new elective course related to BIM management in order to promote graduates who are able to manage the whole construction process with greater efficiency. These efficiencies are acquired through more accurate prototyping, simulation, costing, planning, design, production, and operation that will act as a data input to Building Information Modelling (BIM) system.

Learning Outcomes:

The learning outcomes that were originally set are updated to involve the understanding and use of BIM in its objectives. Also, students are expected to attain an adequate level in BIM skills in their graduation year.

7.2.2. Case 2

The curriculum structure of the LAU differs from that of the AUB. Therefore, it was seen that BIM implementation is more suitable to start in the second year rather than the first year in order to minimize major changes in the curriculum and allow more flexibility in implementation.

Second Year:

The implementation of BIM starts with the introduction of basic REVIT tools in "Computer Graphics I" module and develops to involve a broader level of REVIT software in the "Computer Graphics II".

Third Year:

Since students should have acquired REVIT skills in the second year, the design studio courses of the third year shall involve digital representation of the projects submissions using REVIT.

Fourth Year:

The fall semester of the fourth year shall involve an update on the design studio courses "Design Workshop I" and "Design Studio VI" to support the use of REVIT in its core content. Also, the "Environmental Design I" module can be updated to make students apply building performance analysis using REVIT for their case study project. The same concept is applied in the spring semester, regarding the REVIT presentation requirements for "Design Studio VII" and "Environmental Design II". Moreover, the module "Building Systems IV" can support the use of REVIT specifically in the structural representations of different construction systems. The summer internship program is the only program to be assigned at the end of the fourth year, which could be updated to include the requirement of practicing at a company that supports BIM use.

Fifth Year:

The final year should reflect the advanced level of acquired BIM skills. Hence, the "Design Studio IX & X" modules should reflect in the presented material, analysis, and illustrations the proficiency of the graduate in REVIT and the submission of the final model in REVIT format.

New Electives

The introduction of two electives is suggested for the curriculum. The first one is "Advanced Building Information Modelling", which is designed for students who are interested in advancing their BIM skills and employment opportunities. The advanced features of this course cover complex topics, such as the creation of custom content with the family editor, conceptual massing tools, curtain walls and custom curtain wall panels, phasing tools, work sets, file linking, formulaic design tools, and adaptive components.

The second elective is "Building Information Management" which was suggested in the previous AUB case having the same material content.

Learning Outcomes:

Eight learning outcomes are initially specified in the curriculum. The implementation of BIM suggests the addition of a new learning outcome which is focused on BIM. The new learning outcome shall be the representation of an adequate level of understanding of BIM concepts, tools, and uses.

7.2.3. Case 3

First Year:

The curriculum structure at the BAU focuses on the development of manual skills and representation techniques at the first year level in the design studio. Digital representation is limited to learning the digital tools with no application in the design studios of the first year. The module on "Computer Graphics" in the spring semester involves 3D AutoCad, Sketch-up, and Photoshop. It is suggested that students learn REVIT in this module as a substitute for the listed software, where they could be introduced as separate elective courses.

Second Year:

The application of BIM and the representation of the project output digitally through REVIT is suggested to take place in the design studio courses of the second year. Students are expected to represent in 3D the building design elements and objects using REVIT related to their design project. Also, the module "Indoor Environmental Control in the spring semester" can benefit from BIM skills through the application of building performance analysis on a project model. The end of the second year is proposed to include an internship program of a 6-week duration in a company which supports the use of BIM.

Third Year:

Similarly, to the previous year, the architectural design studio modules are expected to reflect a more advanced level of BIM skills. Students are expected to deliver at the end of the semester a REVIT model. In parallel, the execution design modules in both semesters could make use of REVIT in drawing and representing the executional drawings in 2D and 3D for a better understanding of the construction systems. The "Environmental Design" module in the spring semester could be updated to include the application of building performance simulations to an existing model in response to an environment using REVIT. Moreover, the module of "Interior Design" could easily adopt BIM through representing the interior spaces and furniture in 3D renders using REVIT. The end of the third year suggests the introduction of a BIM-oriented summer internship program to be assessed with a report submission.

Fourth Year:

At the level of the fourth year, the architectural design studio modules are expected to convey, in addition to the advanced representation methods using REVIT, the simulation results of the building performance applied on the project's model and submitted by the end of the semester. At this level, the execution design courses are more oriented towards the mechanical and electrical disciplines, where architectural students can prepare their models to be developed by mechanical and electrical engineers as a multi-disciplinary group exercise. One of the important modules that could take advantage of the implementation of BIM in the curriculum is the “Specifications and Quantities” course where the application of material takeoff could be practiced using REVIT.

Fifth Year:

The final year of the curriculum should reflect the advanced level of BIM skills that the students should have attained through their graduation project submission that includes the final BIM model, 3D renders, building analysis and high presentation quality all through REVIT.

New Electives:

Similar to previous universities, the introduction of new elective courses offers a wide flexibility within the curriculum. The addition of “Advanced Building Information Modelling” and “Building Information Management” shall support the level of knowledge and understanding expected for students to acquire.

Learning Outcomes:

The existing learning outcomes are expected to reflect the reinforcement of BIM in the concepts, knowledge, and understandings. A new learning outcome that is focused on BIM shall be added where students are expected, at the end of the program, to have full understanding of BIM in its aspects related to concepts, skills, tools, and uses.

7.2.4. Feedback

The final validation and assessment of the three implemented scenarios with each of the delegated university tutors was encouraging and positive. There was common feedback from the tutors who believed that the developed BIM implementation scenario was unique, flexible, and fit to the existing structure of the faculty.

As highlighted previously in the research, resistance to change from the managerial level were the main contributors that hindered previous changes and implementations. When examining the scenario trials, the tutors were supportive towards the BIM implementation strategy, for they did not impose massive changes to the curriculum but rather a gradual and on-point additions, omissions, and adaptations to the curriculum. Tutors tend to be more welcoming and acceptable to new implementations when they sense the flexibility of the implementation process and the adaptation where it is supposed to build up on the existing curriculum structure and enhance it rather than replace it. By showing the process of implementation and defining the new BIM learning outcomes to the modules, tutors sensed the importance of applying BIM within the curriculum structure for real with the existence of a clear plan and defined targets.

The exercise of BIM scenario implementation on three universities was vital to reflect the practicality of the developed framework and to provide reliability through the feedback received from the university tutors. Therefore, the exercise validated the BIM implementation framework on a detailed level.

7.3. Summary

The chapter validated the initially developed framework through three sections. The first section was concerned with a presentation followed by an interview performed with professionals in order to discuss the framework and receive feedback. Interviewers expressed the clarity of the framework and reflected support and encouragement in implementing the developed framework. The majority of the interviews agreed with the structure and the approach of the framework regarding the modules and the gradual implementation process. They also supported the necessity of a BIM-oriented summer internship in the program. Recommendations were concerned on the flexibility of implementation and the breaking down of the learning outcomes per module and per year.

The second section covered a practical exercise in implementing the developed framework on three existing architecture curriculums of Lebanese universities. The implementation exercise specifies each year the courses to be updated in terms of material, description, and learning outcomes in compliance with BIM adoption. Furthermore, it suggested the renaming, switching, or removal of some courses to the extent that serves BIM implementation. The third section covered publications performed by the researcher in parallel to this study and as part of the validation process.

Chapter 8 **RESEARCH CONCLUSION**

This final chapter draws up the conclusions of this research. It offers a comprehensive recap of the research aim and objectives and how they were achieved through the research, highlighting the conclusions of each. The chapter furthermore describes the contribution to knowledge that the research adds value to. The chapter moreover presents the final conclusions of the whole research and provides an outline of recommendations for future researchers.

8.1. Introduction

The purpose of this research was to develop a flexible and effective framework for BIM implementation in the Lebanese undergraduate architectural curricula. The motivation behind the aim was to offer a practical framework in response to predefined problems and gaps indicated by initial investigation. The framework delivers adequate BIM knowledge, supports its use, and guides its implementation. Hence, the structure of the thesis research chapters and the adopted approach for the research methodology were selected in response to the research questions and objectives - defined earlier in Chapter One. The second chapter, which covered the previous literature research around the world, specifically UK and Lebanon, helped in defining the existing situation of BIM within the AEC industry and the academic field, focusing on major topics of awareness, understanding, and implementation. Moreover, the literature review supported the process of identifying the gaps that were hindering or limiting the adequate implementation of BIM in the academic and practical fields. The third chapter covered the missing part of the literature review about the BIM Lebanese situation, where interviews were conducted about the educational and industrial systems in Lebanon. Then, the fourth chapter discussed the methodology adopted in this research as a supportive strategy that serves the primary aim and objectives of this study. The fifth chapter covered the process of data collection in its quantitative and qualitative forms. It moreover involved the analysis of this data and the formulation of a list of conclusions. The sixth chapter demonstrated the developed framework of BIM implementation which was built on the findings of the literature review and data collection. The seventh chapter presented the validation of the developed framework through interviews with academics in architecture schools in Lebanon and practical implementation trials on existing undergraduate curricula. Finally, the eighth chapter, which is the current one, discusses the findings and offers recommendations.

8.2. Achievement of the Research Aim and Objectives

Research Aim

The primary aim of this research was to develop a framework that supports the adoption of BIM in undergraduate architectural programmes and curriculums. For this purpose, four objectives were developed to achieve this aim. The appointment of these objectives and their associated final conclusions are explained below.

Objective 1

"To identify the BIM best practice and how it can assist in achieving the learning outcome in architectural education."

The first objective contemplated is to identify and highlight the pillars of this study. The first matter was to explore the foundations of this research through examining the existing situation of BIM implementation in the academic and practical fields in different parts of the world, with a primary focus on the UK, as one of the leading successful examples, and on Lebanon, which is the scope of the framework in this study. The second area of focus was to identify the gaps and challenges that limit the implementation of BIM academically and in professional practice, with a primary focus on the shift from the university to the working environment. The third topic was concerned with identifying the demands of the market which shall be used in the upcoming data collection and hence reduce the gap between the transitional phase from the educational environment to the practical field.

The three areas of focus related to the first objective were all covered in the chapters of the literature review and data collection. The following conclusions were generated:

Definition and Current Status - *Literature Review*:

1. Previous research has conveyed that the definition of BIM is perceived in relation to its use. BIM has been majorly labeled as a visualization tool for

modelling and simulations, a collaborative system which generates an informative model and a process for management and operation of the building.

2. BIM status, characterized by its level of awareness and adoption in the AEC industry, recorded high values in different parts of the world, which were mainly the United States, United Kingdom, Canada, Australia, Denmark, and Japan. However, the rate of BIM implementation revealed lower values. The adoption of BIM in architectural curricula as a stand-alone course in its early implementation forms and then as a design-integrated studio or through partnerships, trainings, and seminars revealed significant improvements.

3. BIM status in the UK is considered a leading example due to the approach of implementation where the government incorporated BIM use in the public projects which have supported the transition towards BIM in the AEC industry and the academic field. In the scope of architectural education programs, BIM adoption witnessed collaboration between different universities in forming a BIM hub which supports the self-learning process. The UK architecture curriculum, furthermore, adopted BIM as a standalone or integrated module.

4. BIM status in the Middle East region recorded a rapid growing rate in response to increasing population, market demand, and technological implications, even if it was lower than in other parts of the world. BIM implementation is supported in the AEC industry, yet there is no governmental requirement to adopt it. In the academic field, BIM implementation is limited to teaching it as a tool only.

5. BIM status in Lebanon is similar to that of the Middle East, where according to previous studies, BIM use in the AEC industry recorded its use by less than half of the consultants and contractors and when it is requested by clients for projects abroad. The adoption of BIM was mainly by large-scale companies and was limited to a drawing and modelling tool to visualize the project and takeoff quantities. Academically, BIM implementation was limited to teaching the course from the perspective of a drawing tool such as REVIT.

Gaps and Barriers - Literature Review and Qualitative Data Collection**:**

1. The first identified gap that faces BIM implementation is taking the decision to do so. Resistance to adopting BIM new technology, which therefore requires changes in systems and updates in personnel skills, stands behind the decision to avoid BIM technology. Having the willingness to accept new technologies is critical to overcome.

2. The second gap that emerged as a result of the first one was the presence of an inadequate level of BIM awareness and correspondingly BIM understanding and knowledge. Professional, academics, and students are aware of BIM at varying levels and through external sources rather than personal experiences with BIM.

3. The third gap was the absence of any obligation to implement BIM in projects by governmental organizational institutions, which sets the standards in construction permits and motivates companies to elevate their quality and standards. On the academic level, there is no requirement that BIM implementation in the curriculum structure be imposed by accreditation bodies such as RIBA, ACCE, or ABET. This furthermore demotivates academic institutions to implement BIM since it neither has an effect on their accreditation status nor delivered quality.

4. The fourth gap is recorded as the lack of any structured framework that acts as a guideline to companies and academic institutions that want to implement BIM in their s. This forms pressure on companies and institutions since they do not know how to organize the implementation process or from where to start, so they end up avoiding the confusion of BIM implementation approach.

5. The fifth gap is related to the implications of cost, time, and change. Implementing BIM at the AEC industry level or the academic level involves the allocation of a budget for the purpose of training the staff or tutors on BIM use and the update or installation of compatible software. The process is, moreover, considered time consuming to fit in within the working load of companies or the compacted curriculum of universities.

6. The sixth gap is associated with concerns on the market and academic levels. For the AEC industry, BIM implementation involves a change in the working method and risks in the successful delivery of complex projects for a company that recently started with BIM application. This threatens the profits of the company. For the academic part, BIM implementation concerns are focused on the limitation of creativity in students who might have technical issues in developing their ideas and creating complex models which require the need for a technical assistant and therefore impose extra costs on the universities.

Market Demands - Qualitative Data Collection:

1. The new market demands associated with BIM technology are reflected in new job roles and new skills requirements. BIM-related positions and duties involve the knowledge and experience of BIM. Graduates or professionals who are not familiar with BIM implementation are disqualified for BIM career roles. Moreover, companies which support BIM in their working methods require personnel who are proficient with BIM. Hence, job screenings and interviews filter applicants based on the competencies of BIM skills, especially for fresh graduates. The graduation of students with the lack of BIM skills lowers their level of competitiveness and decreases their chances in attaining job opportunities in Lebanon and worldwide.

2. There exists confusion when it comes to shifting from the academic level to the professional level. For fresh graduates, the acquisition of a developed level of BIM skills and the experience in practicing BIM relies on students receiving the required level of BIM knowledge and skills development since the early years of the undergraduate architecture program.

Objective 2

"To investigate the current implementation of BIM methods and approaches within academia."

The acquisition of BIM skills is established in the early years of the undergraduate architectural curriculum. The process of integrating BIM into the core courses of the architecture program shapes the curriculum and imposes innovative pedagogical approaches. To further explore the challenges and gaps limiting BIM implementation in academia, a deep assessment of the existing BIM implementation methods and approaches was performed to detect the weaknesses and opportunities in them. The learning approaches and implementation methods explored in the literature review chapter of curriculum examples which have implemented BIM in its program and through the semi-structure interviews with tutors in the data collection chapter. The following conclusions were generated:

Learning Approach– Literature Review:

1. An early approach to incorporating BIM into the architectural program by most universities was the implementation of BIM as a standalone course in the form of a computer-aided module represented with REVIT. This approach is considered a safe one since it does not impose major changes to the curriculum structure and requires the training or employment of one tutor and the update of the computer lab software. Students develop in this approach their BIM skills and learn the features of the tool.

2. A more detailed approach is represented with an integrated design solution for BIM implementation where BIM is adopted in core design studio courses. This approach was seen as the most effective one since it involves the practical implementation of BIM by students within their designed projects, which allows them to build a deep understanding of BIM.

3. A more comprehensive BIM learning approach is the collaborative one. The approach involves the collaboration between inter-disciplines of architecture

students from different years or between multi-disciplines of students with different engineering backgrounds to solve a design problem using BIM system. The collaborative nature of this approach supports the coordination and communication between students with different BIM levels and different engineering disciplines, which is a replica of the professional working environment.

4. An innovative approach in supporting BIM learning is through distance learning, where online platforms are rapidly growing between students from all parts of the world that enable them to share their BIM knowledge and experience in a single learning hub. The approach offers a flexible choice for students and is based on the self-taught method. It has been recorded as a successful and favorable choice for students since they can control the speed of delivery, time, and location.

Implementation Methods – *Data Collection:*

The current implementation methods of BIM in the architecture curriculum were further explored in the semi-structured interviews with tutors, where several interview questions were dedicated for this purpose. Conclusions can be summarized as follows: it is important to teach students to accept a new tool and learn it, whether it is BIM in the current situation or another new technology. Students should learn how to adapt to the change in working methods. Tutors supported the implementation of BIM gradually as a standalone course in the early years and shifted towards BIM design integrated courses, such as architecture design studios and execution design courses. The standalone course was also suggested to offer the learning material of BIM gradually where students can move from the object scale to the whole project scale in the case of computer-aided software, and the importance of learning BIM as a management tool in its quantity takeoff and scheduling forms. Tutors have furthermore agreed on the fact that incorporating BIM into design studio projects keeps students motivated in applying the benefits of BIM to promote their own design.

Objective 3

"To develop a framework for integrating BIM within the undergraduate architectural programmes aligned to current learning objectives."

The purpose of the third objective was to develop an adequate framework for BIM implementation that takes into account all the lessons learned from previous findings of the literature review and the data collection. The primary focus in developing the framework was to respond to the concerns raised by professionals, academics, and students and to offer practical solutions that support and encourage BIM implementation, in the Lebanese architecture curriculum in specific. Also, to ensure a solid transition from the educational phase to the professional practice. The conclusions generated in different sections can be outlined as follows:

Semi-Structured Interviews – *Data Collection:*

1. BIM should not replace manual hand skills nor limit students' creativity, but rather support their development of ideas at further stages.

2. Tutors recommended the implementation of BIM should start in early stages of the architecture program as standalone courses or within courses in the form of theoretical approaches.

3. At advanced learning years, BIM implementation should be reflected in the design studio courses and in management courses, which are mostly similar to the professional practice working environment.

5. Tutors stressed on the necessity of the framework to include a BIM internship obligation for students to practice at offices that support BIM within its working framework to strengthen their BIM knowledge and allow them to improve their experience.

4. Interviewers supported the establishment of a BIM learning hub for students as part of a self-learning effort and the presence of a BIM technical assistant to support them with technical issues or the development of complex ideas.

5. Tutors advised that the framework should encourage collaboration between senior-level students with advanced BIM experience, with students from lower levels, and with less BIM experience. They also encouraged the collaboration of architecture students with different engineering faculties at the senior level as a final exercise for BIM collaboration before heading towards the real-life working experience at offices.

Developed Framework– Framework Development:

The translation of all the gathered and assessed data is reflected in the developed framework, which provides a solution for the existing gaps and organizes the steps for implementation in a flexible manner. The developed framework was structured on the basis of considering the planning the desired outcomes of BIM aspects and scales, developing new learning outcomes, and implementing the plan. The conclusions for each section are outlined as follows:

BIM Aspects & Scales:

1. The building of BIM aspects and scales occurs in a gradual manner moving from simplified ideas to more complex ones.

2. The first aspect involves the theoretical part which shall be implemented in the early years of the architecture program as a stand-alone course which covers the theories of BIM.

3. The second aspect is reflected with BIM being taught as a modelling tool in the form of a standalone course.

4. The third one is the practical aspects where BIM implementation involves the more advanced levels and the design studio courses which takes application on gradual scales: the object scale, the project scale, and the detailed scale.

5. The final aspect is reflected in the whole system of BIM as an integrated system and to be reflected in the final year of graduation.

BIM New Learning Outcomes:

1. The pedagogical approach to BIM requires an update of the learning outcomes to involve new BIM expected outcomes.

2. The curriculum's learning outcomes should be updated to cover tools which develop BIM skills up to a proficient level.

3. The curriculum's learning outcomes should be restructured to reflect the theoretical knowledge of BIM roles and capabilities in the student's work.

4. The curriculum's learning outcomes should be restructured to demonstrate BIM knowledge and understanding through practical application of BIM skills and evaluation performed through assessment.

Implementation Plan:

1. The first step in implementation involves updating the existing courses to involve BIM where applicable. An independent approach suggested establishing a BIM hub for students and teachers to support them with their BIM-related questions and issues.

2. The second step is the introduction of BIM in the form of standalone courses that cover the theoretical aspects of BIM or its tool aspect.

3. The final step is the integration of BIM in its practical aspect within design studio courses or through external courses that support the practical aspect of implementation.

Objective 4

"To validate the framework through peer review and educational and professional opinion."

The purpose of the fourth objective was to discuss the developed framework with professionals and academics to evaluate, firstly, the clarity of the framework and if it is easy to digest and to gather their view points on whether they would be motivated to apply it or suggest perform some modifications.

The framework was introduced to the interviewers as a presentation and then followed by one-to-one interview discussions. The researcher furthermore attempted to apply the framework to 3 existing Lebanese curricula for further verification. The following conclusions were highlighted:

1. No difficulties were recorded concerning the clarity and structure of the framework. Interviewers expressed that the content of the framework was easy to understand and straight to the point.

2. None of the interviewers objected to the non-willingness to implement the framework. Supportive views focused on the flexibility of the framework where it could be implemented at different levels of the curriculum and through a gradual manner. Interviewers believed that the framework was adaptive in its structure to curriculums where application could occur case by case.

3. Interviewers believed that the implementation of the framework was to be a successful one with useful benefits for academics, students, and professionals at a further stage.

4. Interviews highlighted the importance of the flexibility of the framework and the breaking down of the learning outcomes, which enables universities to digest the material and implement it gradually with minor changes.

5. The application of the framework on Lebanese existing curriculum examples proved to be an adaptive and successful one. The framework demonstrated flexibility and the ability to be integrated into a unique curriculum.

8.3. The Contribution to Knowledge

This research is the first of its kind in Lebanon, where it provides a set of guidelines for the gradual implementation and transition to BIM-oriented curriculum content with minimal changes in the curriculum and with the support of the university's own effort.

- This research presents guidance for every academic institution that is willing to adopt BIM within its architectural curriculum at the undergraduate level in Lebanon with the five year program. The new method of implementation (Mixed method), never adopted before in Lebanon, will facilitate the fusion of the BIM within the whole curriculum from the first to the last year.

- The document supports the implementation process where it clearly states and explains the capabilities of BIM in architecture education in Lebanon and details how BIM implementation can improve the quality of the undergraduate program, in order to well prepare the students for the market demands. The research presents extensive information which allows readers to develop a better understanding of the correlation between the new BIM technology and architecture education.

- In Lebanon, BIM-related topics are missing. This research could be a good reference reporting the latest situation of BIM in Lebanon on both educational and industrial levels. In addition, to fulfil the missing data about the general educational situation in the country. And the data collected within this research will work as a solid foundation for any further research related to BIM in Lebanon.

8.4. Research Conclusion

This research draws up a list of conclusions about BIM implementation from the data collected in the literature review, semi-structured interviews, previous surveys, and validation of the developed framework. The study included discussion with professionals, academics, and students. The main conclusions are summarized below:

- This study eliminates the so long dominating idea which limits BIM as a modelling tool.
- The study provides a deep understanding of BIM capabilities, advantages, and problems and offers concrete solutions and action plans.
- The study sets a framework plan to start implementation, taking into consideration the different status and starting point.
- The study stresses on the changes in education that are happening and can be summarized as preparation, development and improvement.
- The implementation process of BIM is a complex one, but it is simplified when the implementation steps are broken down and when flexibility is taken into consideration.
- BIM changes the working scheme in the AEC industry and imposes new job roles. The adaptation of resources to BIM is a main barrier and to overcome it individuals in the field need to be up to date with the new tools of BIM and should convey the understanding of BIM tool and adapt to the changes in the practice.
- Architectural engineering curriculums define the skills and capabilities of graduates which should serve the demand of the AEC industry. The introduction of a new technology within the working scheme should be reflected with an update within the curriculum structure.
- BIM system collaboration is better achieved when the architectural program at the university involves a replica of the practical working

environment. Communication and teamwork between students from different engineering disciplines is a vital exercise.

8.5. Recommendation and Future Improvements

This section provides a list of recommendations for future researchers who are interested in the domain of BIM with a great focus on its implementation in education and in the working field. The recorded results in this research suggest the need to further go into certain topics. The research is moreover limited within a specific timeframe and scope of study; therefore, future studies shall consider an area of interest that supports or extends beyond this study. The suggested list of recommendations is as follows:

- it is recommended to use this thesis as a guideline to prepare a standard implementation process by the order of engineers in Lebanon
- It is recommended to use this thesis by any institution that is willing to implement BIM within its curriculum and to consider it as a foundation for its plan
- It is recommended to update the data about the Lebanese situation of BIM, to facilitate further researches and studies.
- It is recommended that the order of engineers in Lebanon offer more conferences and symposiums about BIM and its benefits and methods of implementation

8.6. Further studies

- Detailed studies about how BIM can assist within each course of the architectural curriculum
- Studying the connection between BIM and other architectural systems
- Further studies about the Lebanese architectural education situation especially in the online era in the time of Covid-19

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APPENDICES

Review of Training Courses Undertaken

Smarthinking – 24/7 Online Writing Support - Brian Dunsmore

The presentation introduces the concept of Smart thinking as an online writing feedback service that operates 24/7 to support students with their written work. Students get to submit their work, have a live chat and receive feedback within 24 hrs about the research grammar, writing structure, arguments, examples, analysis, organization, etc. The presentation shares different feedback form users and students. It moreover highlights when it should be used. This online platform is very helpful, especially for the last time period during COVID-19 where most communication methods were shifted to an online mode.

Introduction to Quantitative research

The training introduces the basis of quantitative research where it highlights the reasons to use it and comparing it versus the qualitative research method. The quantitative research deals with 4 main parts which include: measurement process of quantitative information, sampling methods, design of the research structure and the statistical procedures to filter the types and levels of data, determine the deviations and perform analysis. Since this thesis is built on a quantitative research method and involved questionnaires at multiple points, it was very beneficial to understand all the important aspect of the quantitative research.

The Viva: preparing for the final chapter of your PhD - Dr. Athena Moustaka

The presentation acts as a guideline for preparing the final chapter of the Phd, the VIVA report. It explains the need for a VIVA report and sets the track on how to prepare it. It moreover highlights on what to expect during a VIVA presentation and what standards are needed to demonstrate. Potential outcomes and frequent questions and answers along with past experiences from students are discussed. This training was important to prepare myself as a Phd student for the final output of my research and know what to expect in the VIVA presentation.

Introduction to five Research Strategies – PGRT

The presentation focuses on the five strategies for research. It is divided into two parts. The first one introduces the aim of the research and the systems involved in its inquiry. The second part goes in detail within the general characteristics of qualitative research, correlational research, experimental and quasi-experimental research, simulation and finally some examples of case studies. This training helped in constructing a clear view on the research strategies and differentiate between one another.

Ethical Approval Document

Ethics approval must be obtained by all postgraduate research students (PGR) prior to starting research with human subjects, animals or human tissue.

The student must discuss the content of the form with their dissertation supervisor who will advise them about revisions. A final copy of the summary will then be agreed and the student and supervisor will 'sign it off'.

The signed Ethics Approval Form and application checklist must be e-mailed to your Research Centre Support team in the Research & Enterprise Division:

School of Arts & Media

A&M-ResearchEthics@salford.ac.uk

Salford Business School

SBS-ResearchEthics@salford.ac.uk

School of the Built Environment

S&T-ResearchEthics@salford.ac.uk

School of Computing, Science & Engineering

S&T-ResearchEthics@salford.ac.uk

School of Environment & Life Sciences

S&T-ResearchEthics@salford.ac.uk

For staff and PGR ethics applications to the **School of Health Sciences**, please follow the process as detailed on the Health Ethics website – Click Here.

For staff and PGR ethics applications to the **School of Nursing, Midwifery, Social Work & Social Sciences**, please follow the process as detailed on the Health Ethics website – Click Here.

Application Checklist

The checklist below helps you to ensure that you have all the supporting documentation submitted with your ethics application form. This information is necessary for the Panel to be able to review and approve your application. Please complete the relevant boxes to indicate whether a document is enclosed and where appropriate identifying the date and version number

Document	Enclosed? (Indicate appropriate response)		Date	Version No.
Application form	Mandatory	**If not required, please give a reason**	August 2018	1
Risk Assessment Form	Not Required	The process of interviewing is safe and does not involve any harmful actions. Interviews will be held in a safe and convenient way through the social interfaces.		
Participant Invitation Letter	Not Required	Since participants are located in different parts of the world, the invitation will be via email where a soft copy of the invitation is attached.		
Participant Information Sheet	Yes			
Participant Consent Form	Yes			
Participant Recruitment Material – e.g. copies of posters, newspaper adverts, website	Not Required	The choice of the participants does not involve any advertisement mean. The invitation is sent to candidates that meet the professional level, case study and region of the research scope.		

Organisation Management Consent / Agreement Letter	Not Required	The participants are mostly independent in their businesses and the interview targets their own experience, not the organization's exposure.		
Research Instrument – e.g. questionaire	Not Required	The semi structured interview allows participants to answer questions through multiple choice and free writing answers in order to allow the participant to share his opinion.		
Draft Interview Guide	Yes			
National Research Ethics Committee consent	Not Required	The research does not involve this remit.		

The form must be completed electronically; the sections can be expanded to the size required.

School	Built Environment
Course of Study	Research PhD in Architecture
Has this project received external funding?	NO If **YES**, please provide name of Research Council or other funding organisation: Click here to enter text.
Do you use non-human genetic materials from outside UK for your research?	NO If **YES**, has this been collected since the 12th October 2014? Select

1a. Title of proposed research project
Development of a Framework to Support Embedding Building Information Modelling within Undergraduate Architecture Programmes .
1b. Is this project purely literature based?
Yes ☐ No ☒

2. Project Focus
The research aims to explore the architecture discipline curriculums and extract the learning objectives of the design related modules . In the other side the study identifies the definition of BIM going deeper through the Design Modelling side of the system and clarifies the capabilities and limitations of the it in relation to the learning objectives. This results in developing a framework for the integration of BIM and developing a system that shall assist in achieving learning outcomes for architecture disciplines students , where the system is serving them within the architectural process . The research involves sharing multiple points of view

and experiences by participants from academic and BIM professional backgrounds to better understand the main problem that is hindering the correct implementation.

3. Project Objectives

1. To assess the learning objectives of undergraduate architecture programmes through analysing the performance of the design related courses.
2. To evaluate the requirements of BIM within the architectural sector as a modelling tool.
3. To identify how BIM and new technologies can assist in developing the skills required for architectural undergraduates within the extracted courses.
4. To develop a framework for integrating BIM within the undergraduate architectural programmes that serve in turn the learning objectives (the student outcomes).
5. To validate the framework through the examination of educational and professional opinion.

4. Research Methodology

1- The research takes a transitional approach as it aims in transforming informational theories to be integrated within the architectural education.

2- Since BIM has a socio technical aspect, the adopted approach is the design science research which has its own philosophy and strategies . The research is based on the observations of BIM systems thus gaining an abduction reasoning for the qualitative research . For this purpose, qualitative methods are used to answer questions related to experience, meaning and perspective which is usually from the participant's point of view.

3- This collected data is not subject to measuring. Techniques of qualitative research include (K. Hammarberg et al 2016):

- Small-group discussion that aim in exploring concepts and attitudes of normative behavior.
- Semi-structured interviews that seek views from professionals on a specific topic
- In-depth interviews to gain more understanding on experience and perspectives.
- Analysis of documents to learn more about private knowledge, such as government reports, media articles, websites or diaries

4- Due to the short period of the study, the collection of data related to the academic side will be gathered from document studies . The first source is related to two institutions that follow the RIBA accreditation one on UK and the other will be in the Middle East . The second is the educational report of the ARB and RIBA parties . And the third one is the recruitment requirement exposed by the job agencies .The collected documents can be found on the institutions websites and they are available for public, all institutions or organization names will be unknown and will be anonymous during the research.

5- For the remaining data, interviews with six practitioners and four educators will be performed. Practitioners are chosen three from the UK and three from the MEA region as the RIBA accreditation has a wide influence in these two areas. Two of the educators are under the same institution in the study cases and the other two are involved in the validation phase of the research outcome.

6- As for the interviews, the estimated time is to be 1 hour. It can be held in person or through the social interfaces based upon the interviewee availability.

7- An open discussion is necessary with students to understand how they are looking towards the BIM system and how they relate themselves to the topic. This discussion can be made by attained by inviting students from several universities and can be done in person or by social interfaces also.

8- The collected data will be analysed using manual semantic data analysis to detect a common pattern and to answer research questions from the performed interviews.

Reference:

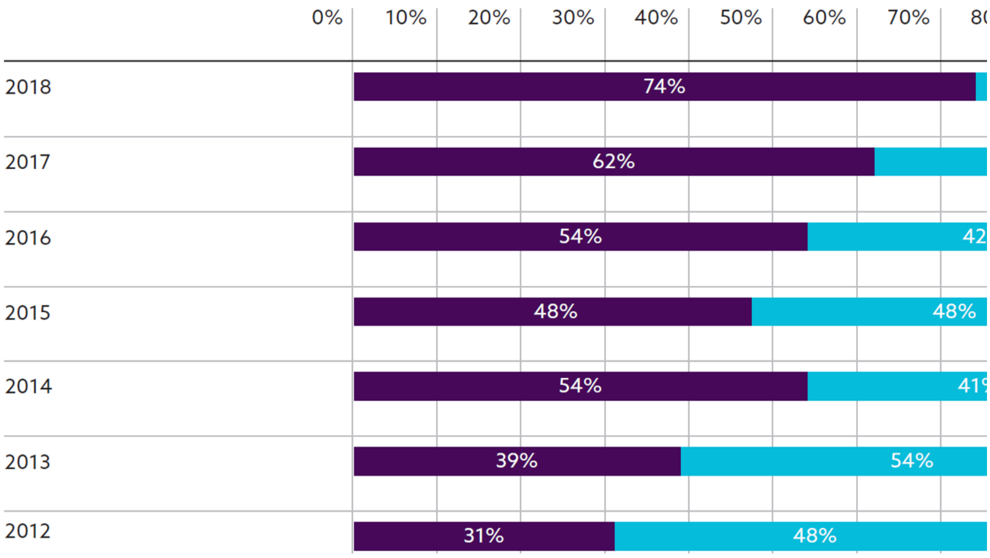
K. Hammarberg, M. Kirkman, S. de Lacey; Qualitative research methods: when to use them and how to judge them, Human Reproduction, Volume 31, Issue 3, 1 March 2016

5. What is the rationale which led to this project?

"As we move towards a digitized built environment we are rapidly having to reassess education against the backdrop of a digital future."

(Philp 2015)

In a changing world of technologies, today's students and professionals need to keep updated with the latest innovations introduced within the industry. This implies that students need to acquire new skills which must be implemented from early undergraduate studies and therefor reflected on the practical field.



BIM Adoption Over Time , NBS report 2018

One of the most powerful tool was Building Information Modelling (BIM) which was introduced to various systems and projects. Yet, BIM remain limited in its use and implementation where it is not reflected in many academic curriculum nor in professional institutions. This implies the existence of a critical problem in BIM implementation on the educational and professional levels. In the previous years, BIM adoption rate has grown significantly in different parts of the world (McGraw-Hill Construction, 2012, NBS, 2018, Jung and Lee, 2015). This approach in BIM adoption was due to the successful delivery of BIM addressing issues issues such as low productivity, poor functionality, rework, and waste at different project and organizational levels (Deutsch, 2011, Smith and Tardif, 2009).

The study explores the implementation approach of BIM in different countries through case studies and semi structured interviews based on the gaps identified from the literature review. The gaps are mainly concerned with the lack of a defined implementation BIM method, lack of BIM implementation framework, lack of academic resources for effective BIM teaching, lack of BIM framework evaluation in undergraduate problems and most importantly the lack of knowledge regarding BIM capabilities in the architectural education sector (Barison & Santos, 2010; Mandhar & Mandhar, 2013; Poerschke et al., 2010). For years, the shift from the educational level to the professional industry has failed to meet the demand of the professional field since the adoption of the new technologies wasn't adequate on all levels (Almutiri 2016). Thus, the outcome fails to prepare graduates for fulfilling the recruitment requirements.

Based on the previously stated gaps and problems, the aim of the research emerged and is defined as developing a framework which combines the traditional learning method in architecture with the new technologies implemented within the curriculum without replacing the existing basis of architectural education. Hence, the motivation of this research is to set an adequate framework that guides universities how to adopt new BIM technologies in their existing courses to serve the market demands and prepare students to face the real life field challenges.

The outcome of the study shall develop a complete framework that is ready for implementation within the architectural education system. The guidelines and recommendations set in the framework for BIM implementation on the educational and professional level achieves learning objectives, expands BIM knowledge and understanding to become a fundamental part of the curriculum and to be reflected on the practical work field as well.

References :

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Mandhar, M., & Mandhar, M. (2013). BIMing the architectural curricula: integrating Building Information Modelling (BIM) in architectural education. International Journal of Technology and Design Education.

McGraw-Hill. (2012). The business value of BIM in North America: multi-year trend analysis and user ratings (2007-2012): Smart Market Report. New York: McGraw-Hill.

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Philp, D. (2015) Current Position and Associated Challenges of BIM Education in UK Higher Education, BIM Academic Forum 2015

Poerschke, U., Holland, R. J., Messner, J. I., & Pihlak, M. (2010). BIM collaboration across six disciplines.

Smith, D. K. and Tardif, M. (2009). Building Information Modeling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers, Hoboken, John Wiley & Sons.

6. If you are going to work within a particular organisation, do they have their own procedures for gaining ethical approval?
(E.g. within a hospital or health centre?). Yes ☐ No ☒ If **YES** – what are these and how will you ensure you meet their requirements? Click here to enter text.

7. Are you going to approach individuals to be involved in your research?
(E.g. within a hospital or health centre?). Yes ☒ No ☐ If **YES** – think about key issues – for example, how you will recruit people? How you will deal with issues of confidentiality/anonymity? Then make notes that cover the key issues linked to your study. The approach to potential participants is through a formal invitation letter sent via email, since not all participants reside in the same country. Along the invitation letter, a participant information sheet will also be provided. The content of these documents will clear out why it is important for the participants to take part in the survey, explain more about the research and what it aims in achieving through the participant's added value from their feedback, discuss issues related to confidentiality and anonymity, consent and data protection. The aim is to gain the participant's trust and encourage him to take part of the survey.

8. More specifically, how will you ensure you gain informed consent from anyone involved in the study?
As explained briefly in the previous point, participants will be informed through an information sheet that explains all details about their participation. They will also be given the opportunity to ask any question during any phase of the survey process. The act of participation is therefore completely voluntary. Each participant will have a copy of the consent form which is attached to this application for ethics approval. Each participant shall sign two copies of the consent form, one retained by him and one by the researcher.

9. How are you going to address any Data Protection issues?
Participant information must remain confidential and anonymous to secure all information collected. The handling and storage of all data must be kept and on a password protected drive, which will be deleted once the work is completed.

10. Are there any other ethical issues that need to be considered? E.g. Research on animals or research involving people under the age of 18.
No

11 (a) Does the project involve the use of ionising or other type of "radiation"
Yes ☐ No ☒
11 (b) Is the use of radiation in this project over and above what would normally be expected? E.g. in diagnostic imaging?
Yes ☐ No ☒
11 (c) Does the project require the use of hazardous substances?
Yes ☐ No ☒
11 (d) Does the project carry any risk of injury to the participants?
Yes ☐ No ☒
11 (e) Does the project require participants to answer questions that may cause disquiet/or upset to them?
Yes ☐ No ☒

If the answer to any of the questions 11(a)-(e) is **YES**, a risk assessment of the project is required and must be submitted with your application.

12. How many subjects will be recruited / involved in the study / research? What is the rationale behind this number?

The interview is expected to target approximately 6 practitioners and 4 educators . This number is based upon the expectation of inviting approximately 20 persons to be interviewed and to get an acceptance response from 50% of them as most of them should be involved in this research and interested to share with me their experience . And this number will give me the right information I need from the interviewees avoiding repetitions and similar answers .

13. Please state which code of ethics has guided your approach (e.g. From Research Council, Professional Body etc).
University of Salford Ethical Approval Process has guided the approach.

Remember that informed consent from research participants is crucial; therefore all documentation must use language that is readily understood by the target audience. Projects that involve NHS patients, patients' records or NHS staff, will require ethics approval by the appropriate NHS Research Ethics Committee. The University Ethics Panel will require written confirmation that such approval has been granted. Where a project forms part of a larger, already approved, project, the approving REC should be informed about, and approve, the use of an additional co-researcher.

Consent Form

Informed Consent for the Development of a Framework to Support Embedding BIM within Undergraduate Architecture Programmes

Please tick the appropriate boxes	Yes	No
1. Taking part in the study		
I have read and understood the study information dated 22/07/2018, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
I understand that taking part in the study involves no individual identification, all collected answers are recorded as written note.	☐	☐
2. Use of the information in the study		
I understand that information I provide will be used solely to improve the current understanding of BIM in architecture education and to promote its implementation within the curriculum.	☐	☐
I understand that personal information collected about me that can identify me, such as my name or where I live, will not be shared beyond the study team.	☐	☐
I agree that my information can be quoted in research outputs.	☐	☐
3. Future use and reuse of the information by others		
I give permission for the survey database that I provide to be deposited in the library of The University of Salford so it can be used for future research and learning. The deposited data will be de-identified where only responses of the participant is shown.	☐	☐

4. Signatures

Name of participant [IN CAPITALS]   Signature   Date

For participants unable to sign their name, mark the box instead of signing ☐

I have witnessed the accurate reading of the consent form with the potential participant and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Name of witness [IN CAPITALS]   Signature   Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Name of researcher [IN CAPITALS]   Signature   Date

INFORMED CONSENT FORM TEMPLATE   PRODUCED BY UK DATA SERVICE

Participant Information Sheet

1. Research Project Title

Development of a Framework to Support Embedding BIM within Undergraduate Architecture Programmes

2. Invitation

I, Ali Hassan Rachid, would like to invite you to take part of my research project. Before you decide to do so, it's important to understand why the research is being done and what will contribution add to it. Please take the time to read the following information carefully and ask questions about anything you do not understand.

3. What is the purpose of the research?

The purpose of this research is to develop a general framework that supports the adoption of BIM in undergraduate architecture programs and curriculums. The study is based on previous findings of literature and is based in a big part on the experience and view of BIM specialists therefore your knowledge adds a great value to the outputs of this research in order to better develop a framework to be implemented.

4. Why have you been chosen?

You have been chosen because the research interview is limited to BIM professionals who have a thorough knowledge in BIM field and are able to share their experiences about BIM implementation.

5. Do I have to participate?

It is solely your decision whether or not you take part in this research. If you decide to take part you will be take a copy of this information sheet and you will indicate your agreement to the online consent form. However, you can still withdraw at any time without giving any reason.

6. What will happen if you participate?

You will be asked to complete an online questionnaire which will take you approximately 15 minutes. You may also wish to agree to a follow-up interview to find out more about your approach.

7. What are the possible risks of taking part?

Participating in this research is not anticipated to cause you any risk or discomfort. Please feel safe in participating.

8. What are the possible benefits of taking part?

Although there are no direct benefits for the participants, it is hoped that this research will have a great beneficial impact on how BIM is implemented in architectural education and therefor reflected on the practical field. The outcomes of this research, which is a generated framework for BIM implementation, will be shared with participants in order to inform their professional work.

9. What happens if the research study stops earlier than expected?

Should the research be terminated for any reason, you will be informed and provided with the reasons.

10. What if something goes wrong?

If you have any complaints about the research or questionnaire process, you can contact any member of the research team (see below).

11. Will my participation in this project be kept confidential?

All the collected information about you during the course of the research will be kept strictly confidential. You will not be identifiable in any reports or publications. Your institution, if mentioned, will also not be identified. All data collected in the online questionnaire will be stored online in a form protected by passwords and other relevant strict security processes. Data collected may be shared in an anonymized form to allow reuse by the research team and other third parties.

12. Will I be recorded, and how will the recorded media be used?

No video or audio recordings are taken other than your input to the questionnaire without separate permission being gained from you.

13. What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?

The questionnaire will mainly involve your input related to your individual experience and opinion regarding BIM implementation. Your views and experience are just what the research is interested in exploring.

14. What will happen to the results of the research project?

Results of the research will be analyzed, developed and published. If you wish to be given a copy of any reports resulting from the research, please ask us to put you on our circulation list.

15. Who has ethically reviewed the project?

This project has been ethically approved by the Information School's ethics review procedure and subsequently endorsed by the ethics procedures of The University of Salford. A copy of the ethical approval is provided to you if you wish.

16. Contacts for further information

Researcher: x

Email: x

Phone: x

Supervisor: x

Email: x

Phone: x

Participant Invitation Letter

‘ Development of a Framework to Support Embedding Building Information Modelling within Undergraduate Architectural Programmes.’

Dear Participant,

You are kindly invited to take part of my research survey entitled: “Development of a framework to Support Embedding BIM within Undergraduate Architecture Programmes”. The purpose of this feedback is to gain your experience and perspective about BIM implementation.

Below is a link to the online survey. Your responses will be kept completely confidential. The survey is web based and conducted by a third party vendor. Please read carefully the information sheet which shall answer all your questions. The survey is user friendly and you should be able to complete it within 15-20mins or less.

Your willingness to participate is much appreciated and your feedback is valued. My hope is that this process will help in developing a framework to better implement BIM in the architectural education and better serve the architectural industry as well.

If you have any further questions please contact me on:

Researcher: x

Email: x

Phone: x

Thank you for your time.

Name of participant ____________________________ Date ________________

Signature ________________________________

Interview with practitioners

Dear Participant,

As part of my PhD studies at the University of Salford – UK, I am conducting a survey about BIM knowledge and understanding. As a BIM student or professional you are in an ideal position to provide your valuable contribution of information from your own experience.

The interview takes around 10 minutes. Your participation is voluntary and your identity will be kept be anonymous. All responses will be kept confidential. Nevertheless, your participation will be valuable and all findings could lead to greater public understanding of BIM for Modeling an architectural design .

Name of the Participant:

Please specify your profession:

- Architect
- Architectural Engineer
- Civil Engineer
- Mechanical Engineer
- Electrical Engineer
- Electromeachanical Egnineer
- Interior Designer
- Other : ……………….

Name of the association you belong to:

Job Title :

1- As a BIM practitioner how do you classify your work in this sector As a Building information modelling or Building information management and please justify your answer ?

2- How many years of experience do you have?
  - o 0 to 3
  - o 3 to 8
  - o 8 to 12
  - o 12 and above

3- How did you learn the BIM system?
  - o At the university through lectures
  - o Self Learning
  - o Through a certified instructor / academic
  - o Non formal training
  - o From peer learning
  - o Online learning method
  - o Other, please specify: -----------------------------------

How do you rate this way of learning ?

  - o Strongly Agree
  - o Agree
  - o Slightly Agree
  - o Slightly Disagree
  - o Disagree
  - o Strongly Disagree

Justify your answer ? ------------------------------

4- Is BIM for modeling and design implemented where you are working and how?*
  - o Yes
  - o No
  - o If yes, please explain briefly how: --------------------

5- What was the major change when you started by learning and working within the BIM system , and if you used to use CAD system what was the difference between both ?

6- Do you consider learning BIM is due to a personal purpose of knowledge upgradation or a demand from the association / university where you belong ?

7- How do you define BIM within your working field ?

8- How does BIM help you to achieve your working needs as an engineer / teacher / student?

9- Do you find that BIM was essential during your working period?

10-If BIM wasn't implemented in your study ,In your opinion, and after your working experience what could the system add to you at the university?

11-Do you work within a multidisciplinary system? and have you got the training during your study if yes, how ?

- o Yes
- o No

If Yes, did you get the training during the study and how?

- o Yes ___________________________________
- o No

12-In your opinion, how do you see the importance of BIM in the future?

- o Very important
- o Important
- o Not important
- o Don't know

13-In your opinion, what are the greatest benefits of BIM use?

14-In your opinion, what are the limitations / barrier that you are facing while using BIM?

15-Are these limitations coming from a missing point in your knowledge or from a software or lack of system ?

16-In your opinion, where do you see BIM in the future?

Interview with teachers

Dear Participant,

As part of my PhD studies at the University of Salford – UK, I am conducting a survey about BIM knowledge and understanding. As a BIM student or professional you are in an ideal position to provide your valuable contribution of information from your own experience.

The interview takes around 10 minutes. Your participation is voluntary and your identity will be kept be anonymous. All responses will be kept confidential. Nevertheless, your participation will be valuable and all findings could lead to greater public understanding of BIM for Modeling an architectural design .

Name of the Participant:

Please specify your profession:

- o Architect
- o Architectural Engineer
- o Civil Engineer
- o Mechanical Engineer
- o Electrical Engineer
- o Electromeachanical Egnineer
- o Interior Designer
- o Other : ……………….

Name of the association you belong to:

Job Title :

1- How many years of teaching experience do you have?
    - 0 to 3
    - 3 to 8
    - 8 to 12
    - 12 and above

2- Is BIM for modeling and design implemented where you are working and how?
    - Yes
    - No
    - If yes, please explain briefly how: --------------------

3- How do you define BIM within the academic field ?

4- Do you find that BIM was essential during your study period?

5- As a teacher how do you think that BIM could serve the design related modules in the architectural curriculum ?

    - Not Applicable

6- Do you implement BIM within your taught courses? If yes what are these courses?

7- What is the method of implementing BIM in the curriculum?
    - Stand Alone (as a separate course)
    - In course integration (integrated within another quote)

8- Do you teach within a multidisciplinary system? If yes how the disciplines are connected with each other ?

9- What is the level of BIM implemented within the curriculum you are teaching?
    - Freshman

- Sophomore
- Junior
- Senior
- Graduate

10-What is the expected BIM level of your students after graduation?

- Basic level
- Intermediate level
- Advanced level
- Expert level

11-In your opinion, how do you see the importance of BIM in the future?

- Very important
- Important
- Not important
- Don't know

12-In your opinion, what are the benefits of BIM use in comparison with the CAD system ?

13-In your opinion, what are the disadvantages of using BIM within the undergraduate curricular and how we can avoid such gaps ?

14-Have you tough using the CAD system ? if yes what is the major difference between using the BIM and the CAD system ?

15-Are these limitations coming from a missing point in your knowledge or from a software or lack of system ?

16-In your opinion, where do you see BIM in the future?