Ain Shams University.
Egypt.

Digital Transformation:
Architects' readiness in architectural technical offices in Egypt

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design (IUSD)

By: Sandy M. Grant

Supervised by:

Prof. Dr. Abeer Elshater
Professor at Urban Planning
Faculty of Engineering
Ain Shams University

Assist. Prof. Dr. Mohamed Ezzeldin
Assistant Professor at Architecture Engineering
Faculty of Engineering
Ain Shams University

IUSD-Intake X

Cairo, 2022

Digital Transformation:
Architects' readiness in architectural technical offices in Egypt

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

by: **Sandy Grant**

Supervised by:

Prof. Dr. Abeer Elshater	**Assist. Prof. Dr. Mohamed Ezzeldin**
Professor at Urban Planning	Assistant Professor at Architecture Engineering
Faculty of Engineering	Faculty of Engineering
Ain Shams University	Ain Shams University

Examiners Committee

Title, Name & Affiliation	Signature
Prof. Professor of University of	
Prof. Professor of University of	
Prof. Professor of University of	

Date: / /

Ain Shams University

Egypt

Disclaimer

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of Integrated Urbanism and Sustainable Design.

The work included in this thesis was original intellectual product conducted by the author in the year 2021/2022.

The candidate confirms that the work submitted in her own and that appropriate credit has been given where reference has been made to the work of others.

Ain Shams University holds the right to publicly distribute this thesis in the current university standard format. The author holds the right to publish the content in any other format.

31/07/2022

Sandy Grant

Signature

Acknowledgement

It would not have been possible, it could not have been done without the care, advice, and assistance of many.

First and foremost, I am thankful to God for everything, for allowing me to walk this path and giving me the strength and ability to reach my aims and goals, for giving my beloved father and all my beloved ones the chance to witness another success and a baby step towards a bigger dream. Always believing that “I Can Do All Things Through Christ Who Strengthens Me”. - Philippians 4:13

Then, I would like to express my deepest appreciation and gratitude to my academic supervisors. Professor Dr. Abeer Elshater and Assistant Professor Dr. Mohamed Ezzeldin, thank you for the huge support, care, and insightful comments.

Thanks to the IUSD team and Professor Dr. Mohamed Salheen for the opportunity and the knowledge.

I would like to extend my appreciation and love for my friends; Philippe Emad, Yasmina Safwat, Muhammed Darwish, and Sherry Eskarous for their unstoppable support and unconditional help and love.

Last but not least, A special thank you goes to my beloved father Eng. Magdy Grant, my mother Gehan Makram, my two sisters Carol and Mira, and my beloved dog Zeezee for being my all-time backbone and support system.

In the end, I hope this work be beneficial to others.

Thank you,
Sandy.

Abstract

With growing technology needs in late ninetieth, and remarkable rise of new digital technologies, going digital becomes the new trend. Tracks, types, and approaches to adopt technology in several fields as a digital technology-based improvement of doing business specially the architecture profession, beside the unprecedented health crisis of COVID-19 pandemic that works as a catalyst to go digital to minimize the spread of the virus. But No one ever question readiness for such a speedy journey and how architects accept new technologies in their profession.

The aim of this thesis is to investigate readiness of architects in Egyptian architectural technical offices to digital transformation process through a systematic literature review to identify different terminologies related to this topic, mentioning differences among them, scanning global and local cases of adoption of different digital technologies in architecture profession, also explaining and discussing the digital readiness index and technology acceptance model theory coming up with a combined conceptual model of both theories based on which the researcher determines the assessment criteria upon which the questionnaire is designed to be revealed for any architect works in architecture technical office to gather different perceptions and analyze them.

The thesis findings were conducted from analyzing and discussing the results derived from the bibliometric mapping, the questionnaire results and interlinked case study interviews. The contribution of this study is presenting a framework and provide outlook for adopting technologies in architectural firms, organizations, or offices.

Keywords

Digital readiness, technology acceptance, digital transformation in Architecture

Table of Contents

List of Figures

Tables

Chapter 02: Digitalization VS Digital Transformation

Chapter 03: Digital Transformation initiatives

List of Acronyms

AEC	The Architecture, Engineering and Construction
APIs	Application programming interfaces
COVID	Corona Virus Disease (CO – VI – D)
DT	Digital Transformation
ICT	Information and Communication Technology
IRB	Institutional Review Board
MPED	Ministry of Planning and Economic Development
R&D	Research and Development
SDL	Self-directed learning
SME	Small and Medium Enterprise
TAM	Technology Acceptance Model
TOT	Training of Trainers
TR	Technology Readiness
WHO	World Health Organization

Related software used in thesis

VOSviewer a software tool for constructing and visualizing bibliometric networks. These networks may include, for example, individual journals, researchers, or publications, and may be constructed according to citation, bibliographic linkage, joint citation, or co-author relationships. VOS viewer also provides a text exploration feature that can be used to build and visualize networks of co-occurrence of important terms from a body of scientific literature.

Chapter 01: Introduction

Preface

In October 2021 Mark Zuckerberg the founder of Facebook started a live video talking about their vision of the Metaverse. He mentioned things that could be possible because of Metaverse, the experiences that we will have, the creative economy we will build, and the technology that need to be invented. Also, how we are planning to do this together? He also mentioned the basic story of technology in our lifetimes and how it has given us the power to express ourselves and experience the world with ever more extraordinary richness. After that, Zuckerberg highlighted the time he invented Facebook, that mostly typed text that we type on our computers, then we got phones with cameras and the internet became much more visual, and recently as connection got faster, video has become the main way that we experience content. This could be reflected on digital technologies historical timeline, since the early civilizations all sorts of data were documented through analogue and physical tools, and in the 19th century a need for digital technologies revealed.

Adoption of digital technologies which is an actively discussed topic these days, however the world started the computerized processes almost 30 years ago, and digital activities were already implemented in several organizations since George Boole invented the Boolean Algebra which is the foundation of all modern computers. Ever since adoption of technology in industries trials has started through several tracks and further upgrading these technologies through approaches of transformation whether this transformation is a process transformation, business model, domain, organizational or even cultural transformation.

Research problem

Technology has a profound impact on both what architects are able to produce and how they carry out their work over the entire history of architecture. But ever since the digital revolution, the field has gone through a period of significant upheaval. Besides, the new digital era post pandemic is

rapidly moving, it is now the new normal, but no one ever question readiness for such a speedy journey and how architects accept new technologies in their profession. A gap in literature in tackling the readiness of architects in architectural technical offices to the Digital transformation.

1.1 Research Questions

The purpose of this thesis was to answer the following questions:

To what extent are the architects in the architectural offices in Egypt ready to go digital?!

What is digital transformation and what is the difference between this terminology and the digitalization term?

What are different digital transformation initiatives locally and worldwide?

What is digital readiness index/technology acceptance model?

1.2 Research Objectives

This thesis aims to investigate the readiness of architects in Egyptian architectural technical offices to digital transformation process. Our objectives can therefore be restated as follows:

- Illustrate the state of art of digital transformation/digitalization terminologies, provide a better understanding of both and what these terminologies mean in this research specifically.
- Examine a number of global and local initiatives that used various approaches to digital technology adoption in a variety of fields, particularly architecture.
- investigate of models created to evaluate essential aspects of use and acceptability of technology-based products and services; Digital readiness/technology readiness index (TRI) and technology acceptance model (TAM) theories' scales.
- Determination of criteria/proposed research model of assessing architects' digital readiness and design the questionnaire to be revealed for any architect works in architecture technical office to gather different perceptions, analyze them, and produce technology adoption outlook for architectural offices.

1.3 Methodology

This study followed an **exploratory and analytical approaches.** The methodology follows mixed method of deductive and inductive approaches. The theoretical framework of systematic literature review in chapters 02, 03, and 04, and analytical framework which is based on data from a mixed method that follow both qualitative and quantitative approaches using a software in chapter 02 "VOSviewer" to produce bibliometric maps, interviews in chapter 03 and a questionnaire in Chapter 05 (Creswell & Clark, 2011; Greene, Caracelli, & Graham, 1989).

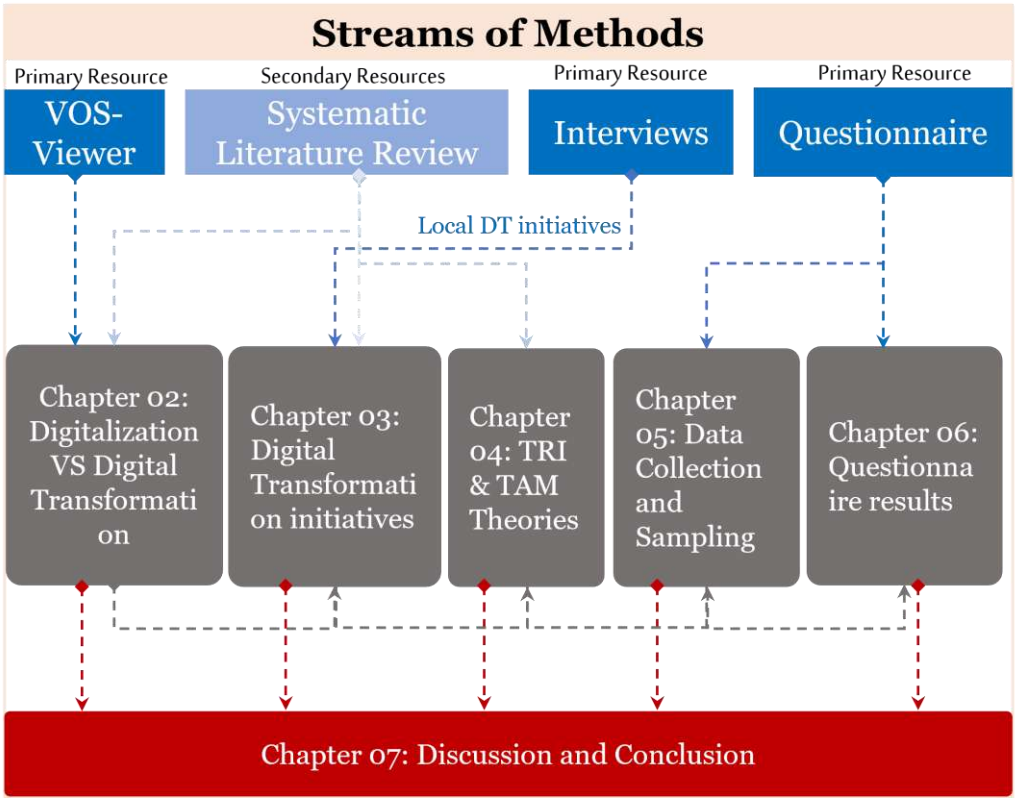


Figure 1 *Streams of Methods – Source: Author*

1.4 Thesis Structure

Part I: Building knowledge

Chapter 02: Digitalization vs Digital Transformation

The aim of this chapter is to identify and illustrate the state of art of these terms, provide a better understanding of both terms' foundations and what these terminologies mean in this research specifically.

To achieve the stated aim, a systematic literature review is employed in order to clarify both digitalization and digital transformation concepts to provide an overview of the existing theory.

Comparative analysis between Digitalization and Digital transformation terminologies based on a systematic literature review based on theoretical framework **(secondary resources)** and analytical framework **(Primary resources – Analysis via VOS Viewer).**

Through the content analysis technique, which can be simply defined as the systematic, objective, quantitative analysis of message characteristics – it included both human-coded analysis and computer-aided text analysis and is widely used to determine the presence of certain words, themes, or concepts within some given qualitative data, in other words to determine the percentage of a text committed to a certain subject, after that data is analyzed

Using VOS-viewer the data has been examined by constructing and visualizing bibliometric co-occurrence networks of these important terms extracted from a body of scientific literature.

Chapter 03: Digital Transformation Initiatives

The goal of this chapter is to examine and dig into several global and local initiatives that used various approaches to digital technology adoption in various fields, particularly architecture.

Investigation of Digital transformation global initiatives is based on Literature review (Theoretical framework- **Secondary resources**) To meet the specified objective of this chapter, a comparative analysis technique is followed to approach digital transformation initiatives in several contexts, describe each experience on its own, understand the different methodologies and tracks of adopting technologies and understand the lessons learned from each, highlighting the pros and cons of each scenario.

Local initiatives are based on open-ended interviews (**Primary Resources-Inductive Method of Analyzing Interview**). The open-ended interview is designed to investigate local initiatives' nature/type, approach, strategy, and outcomes.

The open questions are subjected to a thematic analysis (Bernard, 2011; Guest, MacQueen, & Namey, 2012). Getting patterns from answers and analyze them along with the questionnaire results in chapter 06.

Chapter 04: Digital Readiness and Technology Acceptance Theories

The scope of this chapter covers the study of models created to evaluate essential aspects of use and acceptability of technology-based products and services; Digital readiness/technology readiness index (TRI) and technology acceptance model (TAM) theories' scales, reviewing the elements and the key factors that affect human digital readiness and acceptance for new technology use, developing a new proposed conceptual model to assess readiness and acceptance of architects to technology adoption (Conceptual framework- **Primary and Secondary resources**)

Part II: Applying knowledge

Chapter 05: Materials and Methods

Data collection and Sampling **– Questionnaire structure (Primary Resource)**

The Questionnaire is used to measure technology readiness and acceptance for professional architects working in various architectural offices based on proposed assessment criteria built on literature.

Chapter 06: Analytical framework **– Questionnaire and interviews results analysis (Primary Resource)**

*Regarding this part of the research methodology, the author confirms that Ain Shams University does not establish Institutional Review Board (IRB) at the moment of conducting the current study***.**

Chapter 07: Discussion and Conclusion. (Primary and secondary Resources)

Proposing future outlook for technology adoption in architectural offices.

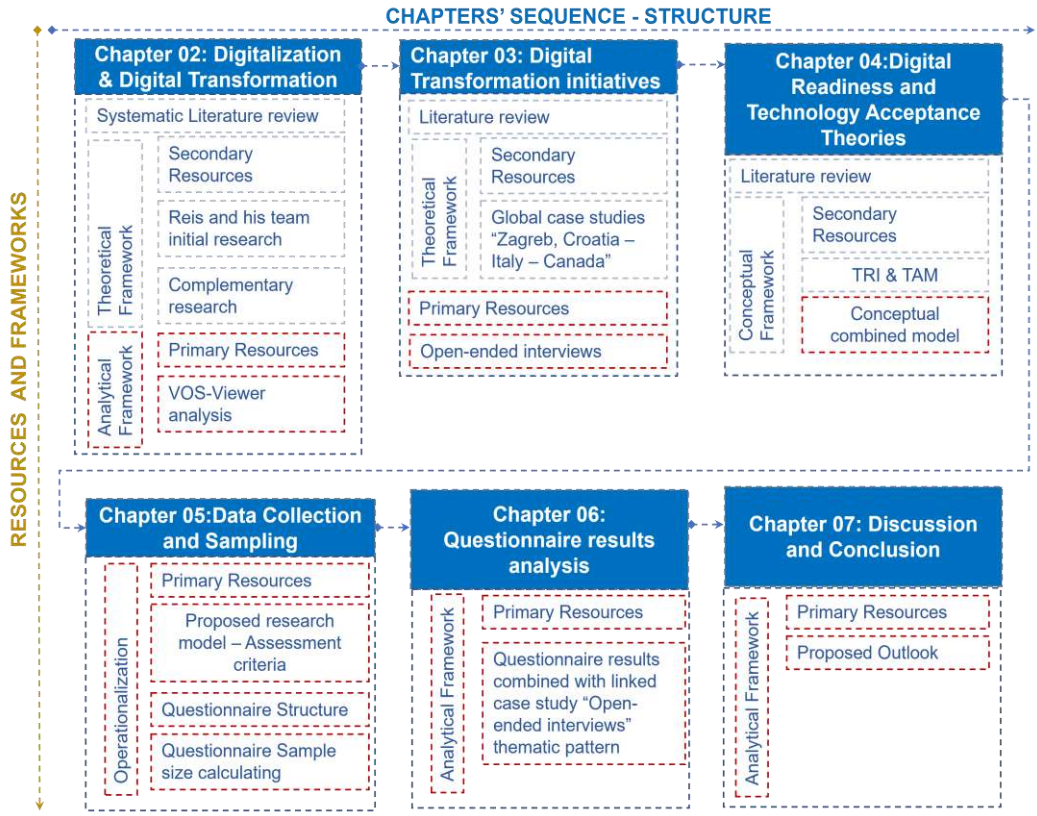


Figure 2 *Thesis Structure & Resources – Source: Author*

1.5 Contribution

This thesis contributes to a better understanding of digital transformation and related terms, in terms of meaning and definitions, networks and nodes in academic research, highlighting several gaps in literature that could be useful for further investigations and research as well. It also helps to look into a number of global and local DT projects and to study readiness and technology acceptance evaluation models.

This thesis is unique as no studies have specifically addressed the relation between Digital transformation and organizational readiness nor human-being readiness or technology acceptance.

The expected results could be in the area of interest for professional practitioners who work in architecture, urban planning, urban design, landscape architecture, building technology, and computational design.

Chapter 02: Digitalization vs Digital Transformation

2.1 Introduction

New digital technologies are changing how we work, communicate, create, build, and maintain relationships. Every area of our existence is being transformed by them. Collaboration and innovation are enabled by a digitally transforming culture. As a result, these have the potential to significantly boost production and efficiency. The development of digital technologies has changed the business environment globally. The advent of new business models provides a greater potential and more opportunities to increase profitability (NBS, 2018).

Digital technologies receive more and more attention in the architecture and construction sector. Therefore, many companies are moving forward and taking steps towards adoption and application of digital technology to capitalize on the prospects (Nasution, Rusnandi, Qodariah, Arnita, & Windasari, 2018). We discovered that 'digital transformation' isn't a familiar term to architects, construction experts and built environment professionals. Regardless of whether they recognize, and understand the terminology or not, the architecture and design community is embracing digital transformation and the benefits it brings (NBS, 2018).

Obviously, this new digital edge is a main concern to practitioners, the question is to what extent this progress is being followed by academics and scholars and how they deal with this concept. The fact is that terminologies like "Digitalization, and Digital transformation", are used in literature interchangeably and refer to a broad concept affecting politics, business, and social issues (Collin, et al., 2015) without an edge that determines differences among them (Reis, Amorim, Melão, Cohen, & Rodrigues, 2020; Reis, Amorim, Melão, & Matos, 2018). So, as explained earlier, the aim of this chapter is to illustrate the state of art of these terminologies and provide a greater comprehension and deeper understanding of both terms, and what these terminologies mean in this research specifically.

Achieving the aim of this chapter through a systematic literature review that is followed in order to clarify both digitalization and digital transformation concepts to provide an overview of the existing theory. Also, following the content analysis technique, to determine the percentage of a text committed to the specified terms, after that data is analyzed. Using VOS-viewer data has been examined by constructing and visualizing bibliometric co-occurrence networks' mapping of these important terms extracted from a body of scientific literature.

2.2 Digitalization

Regarding the term "digitalization", in March 2020, research was produced using Elsevier's Scopus citation database of peer-reviewed literature by a research team of five researchers led by Joao Reis a researcher from Department of Military Science and Technologies, and CISD & CINAMIL, Military Academy in Lisbon, Portugal, with a financial support from the Research Unit of Governance, Competitiveness and Public Policies (GOVCOPP) from Aveiro University – Portugal to create a review and research agenda. The term itself was found 13,194 times in literature in all fields. The primary search criterion was based on the word "digitalization" in the article titles. This preliminary search revealed 1,441 documents, which included journal articles in the English language to enable and allow interpretation (Reis, Amorim, Melão, Cohen, & Rodrigues, 2020).

This initial research contributes to the digitalization literature, by providing a clear understanding and comprehensive knowledge of its roots regarding the advancements achieved in the last few years, it also concluded that more debate on the digitalization agenda is needed to develop a deeper understanding of how digital initiatives are changing existing business models (Reis, Amorim, Melão, Cohen, & Rodrigues, 2020).

To improve this review process and do a complementary systematic literature review using another scientific database which is Clarivate Analytics - web of science database, last reviewed in April 2022 and to justify the choice of a

certain type of articles and not others, several filters were applied to exclude irrelevant papers and save time. Our initial search revealed 16,032 documents in all fields that include the term “Digitalization” and the inclusion criteria focused on English highly cited papers about digitalization in all fields during the past five years between 2018-2022, due to the abundance of empirical evidence, they are the most promising theoretical study topics. The final systematic literature review included 76 published articles.

Table 01. Systematic literature review process – WOS last reviewed April 25, 2022

Web of science database		Documents	Query Link	QR Code for Quick Access
Search term “Digitalization”	All fields	16,040	https://www.webofscience.com/wos/woscc/summary/950f57ce-c77e-43f4-80aa-46f8d46219f5-338eedcf/relevance/1	
Language	English	13,927	https://www.webofscience.com/wos/woscc/summary/14ab9304-4642-4036-a6b8-8e52ed26fb93-	
Duration	In the past five years (2018-2022)	10,360	https://www.webofscience.com/wos/woscc/summary/2a16ded6-6cde-49a4-ac0e-c5f87567c3ff-	
Citation	Highly Cited papers	76	https://www.webofscience.com/wos/woscc/summary/c6391c0a-8aa3-4b0b-96d7-b2e79c997c66-338f35a4/relevance/1	

The query link:

https://www.webofscience.com/wos/woscc/summary/c6391c0a-8aa3-4b0b-96d7-b2e79c997c66-338f35a4/relevance/1

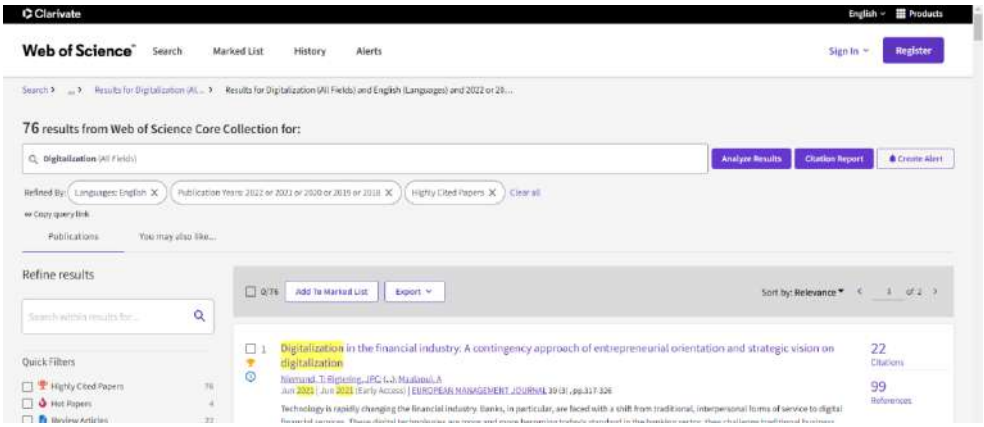


Figure 3 *Snapshot of WOS database review of the term digitalization in English highly cited papers in the past five years 2018-2022*

2.2.1 Gaps in Literature of Digitalization

In the initial research of Joao Reis and his team, they analyzed the data using computer-aided text analysis software which is NVivo 11 – QSR International. It is found that the Nordic European countries are putting investment on the integration of ICT and digitalization processes in new or pre-existing business models. In Fig. 04, the top 10 countries that produced documents related to the topic till 2020, it is obvious that there is a gap in the Middle East.

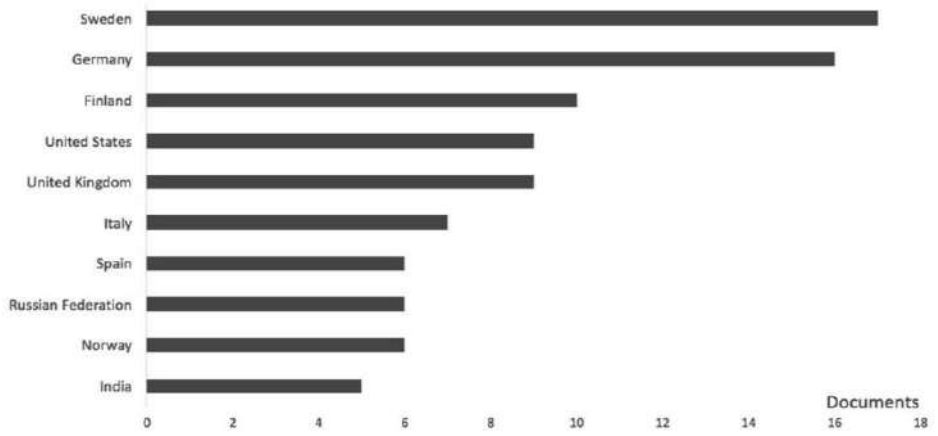


Figure 4 *Documents by country or territory - Source: (Reis, Amorim, Melão, Cohen, & Rodrigues, 2020)*

Remarkably, few articles distinguish between digitalization, digitization, and digitation, which are occasionally used indistinctly in the literature or at the very least, there appears to be some misunderstanding about the terms' usage.

Only a few articles were found that were interested in creating such a distinction. Notable examples are presented by Clerck, where he presented digitalization as “the use or the application of digital technology and data to generate money, improve business, replace/transform business processes, and create a digital business environment in which digital information is at the core" (Clerck, 2017). Interestingly, this research highlighted the limited research regarding the usage of terms, with evidence that this is an area to be explored in future research works. So they analyzed each definition they found and then presented a scholar acdemic debate aound the term, which is summarized in Table 02.

Table 02. Digitalization Definitions. Source: (Reis, Amorim, Melão, Cohen, & Rodrigues, 2020).

Author(s)	Definition
Maxwell and McCain	Information is broken down into its smallest components using digital technologies. Digitalization transforms an analogue signal into distinct components, allowing it to change information, text, pictures, software code, music, and video in previously unimaginable ways, thus its informing and transforming capabilities.
Clerck	Digitalization is the use or the application of digital technology and data to generate money, improve business, replace/transform business processes, and create a digital business environment in which digital information is at the core
Machekhina	Digitalization means transformation of all information types (text, sound, visuals, video and other data from various sources) into the digital language
Eling and Lehmann	The integration of the analogue and digital worlds with new technologies that enhance customer interactions, data availability and business process
Crittenden et al.	Digitalization creates new forms of interaction between companies and customers through channels

Recap of Table 2, the first definition by Maxwell and McCain considered digitalization as the change of analogue signals into digital components. This was supported by Eling and Lehmann (Eling & Lehmann, 2018; Maxwell & McCain, 1997). Whereas Machekhina presented and described digitalization in a broader way, that it is all about transforming all information type to the digital language (Machekhina, 2017).

All of the previous definitions were mainly identified in the socio-economic and organizational literature, and the research team also provided a chart of major and minor subject areas in literature according to Scopus database classification (Scopus: Content Coverage Guide, 2017).

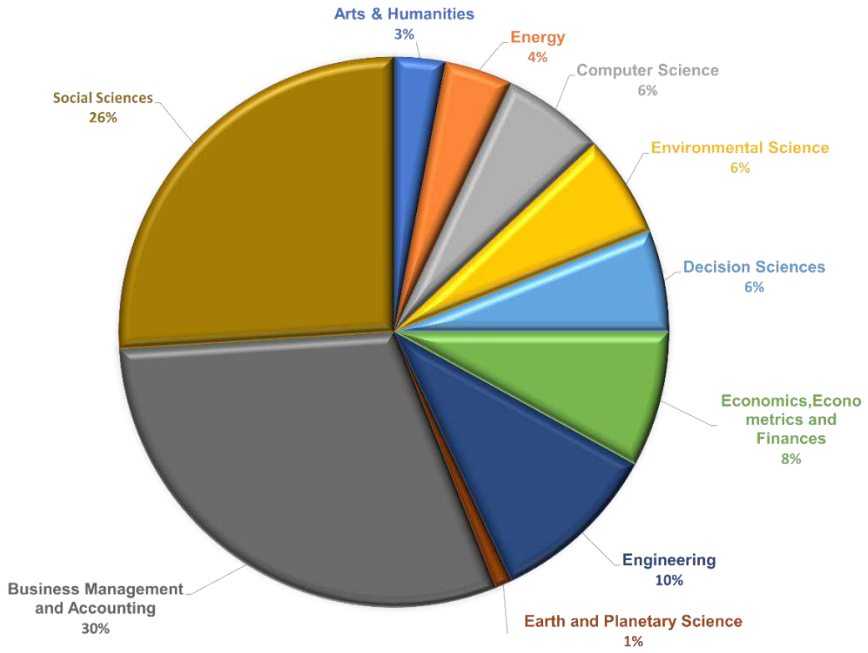


Figure 5 *Documents by subject area. Source: (Reis, Amorim, Melão, Cohen, & Rodrigues, 2020) - Edited by: Author*

New technology breakthroughs and innovations such as the Internet and smartphones have had a dramatic profound significant impact on every aspect of economic, political, and social life over the previous two decades (Hansen & Salskov-Iversen, 2005).

The integration of digital devices rearranged the activities of business organizations; as a result, corporations have begun to achieve market and operational efficiency by implementing business process digitalization (Li, Merenda, & Venkatachalam, 2009). That explains ratios in figure 05.

We can see from Figure 05 that the engineering field has a significant presence in the digitalization scene. However, it is less than that of the Business Management, accounting, and social sciences.

In addition to this with the complementary research in 2022, it is found that documents tackling digitalization slightly increased, however there is still a confusion regarding the definition and the use of the term interchangeably with DT. However certain definitions could be added to the previous scholar debate around the term. In 2018, Gobble defined the term digitalization as the use or the application of digital technology, and, most likely, digitized data, to create and harvest value in novel ways (Gobble, 2018). It could be also defined as the reconstruction of various spheres of social life around digital communication and media infrastructures Essentially stated, digitalization is the application of digital technologies according to Srai and Lorentz (Srai & Lorentz, 2019). In 2020, Mark Sen Gupta a Digital Transformation and Industrial Automation Analyst, Strategist, Consultant, and a director of research supported the previous definitions for digitalization as the use of digital technologies and digitised data to enable or improve processes of any sort of business (Gupta, 2020).

Using VOSviewer to analyze the data, a bibliometric map is produced Figures 06, 07, & 08.

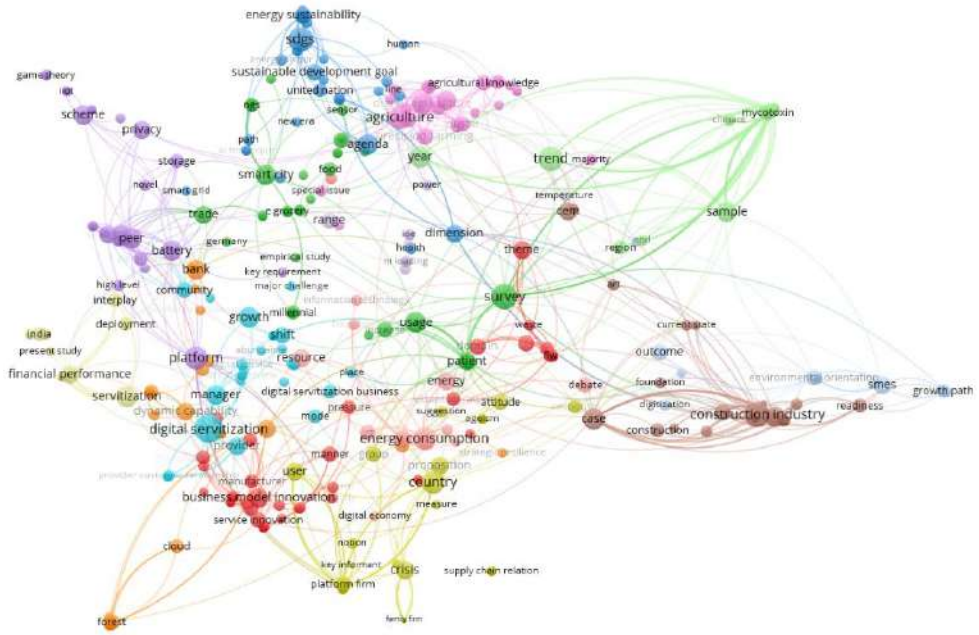


Figure 6 *The bibliometric source mapping of Digitalization based on WOS database highly cited papers during 2018-2022 and analyzed by VOS viewer. Source: Author*

From this map, we can declare that the documents by subject areas in the previous five years could be categorized into seven main groups:

A) Economics, which includes the digital economy, econometrics, and finances.
B) Business management, for instance: digital servitization business
C) the agriculture knowledge
D) Engineering - construction industry
E) Energy track
F) Environmental science
G) Humanities

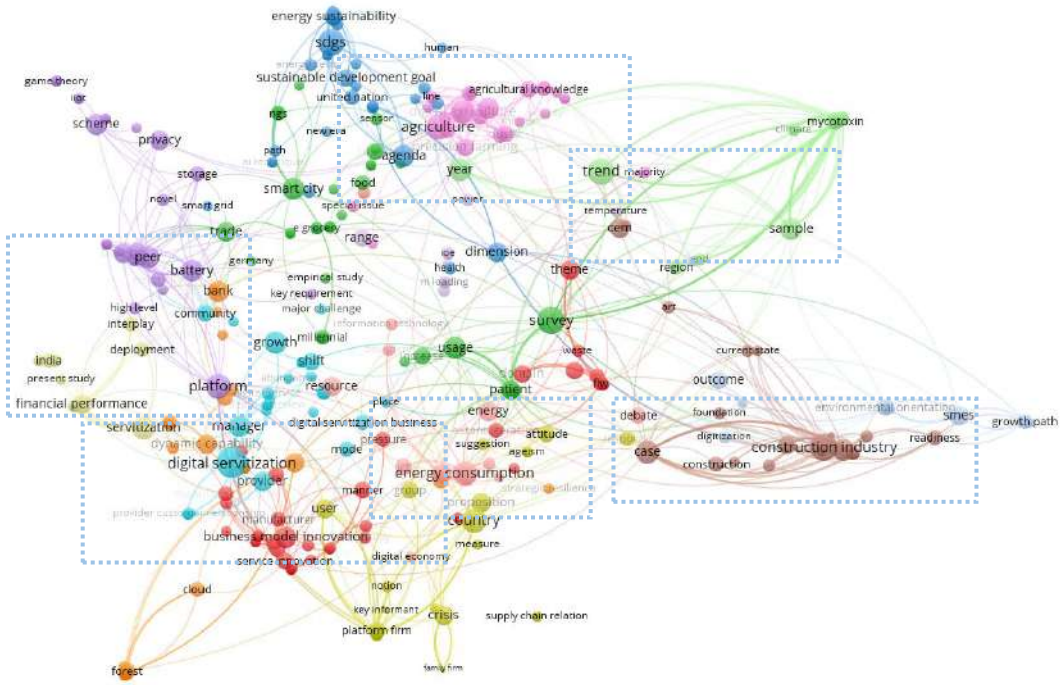


Figure 7 *Highlighting subject areas of publications in the duration 2018-2022 - Source: Author*

There is still a gap in literature about the readiness of users towards new digital technologies in construction industry that includes the architects. No relation has been mentioned till the time this paper is being written.

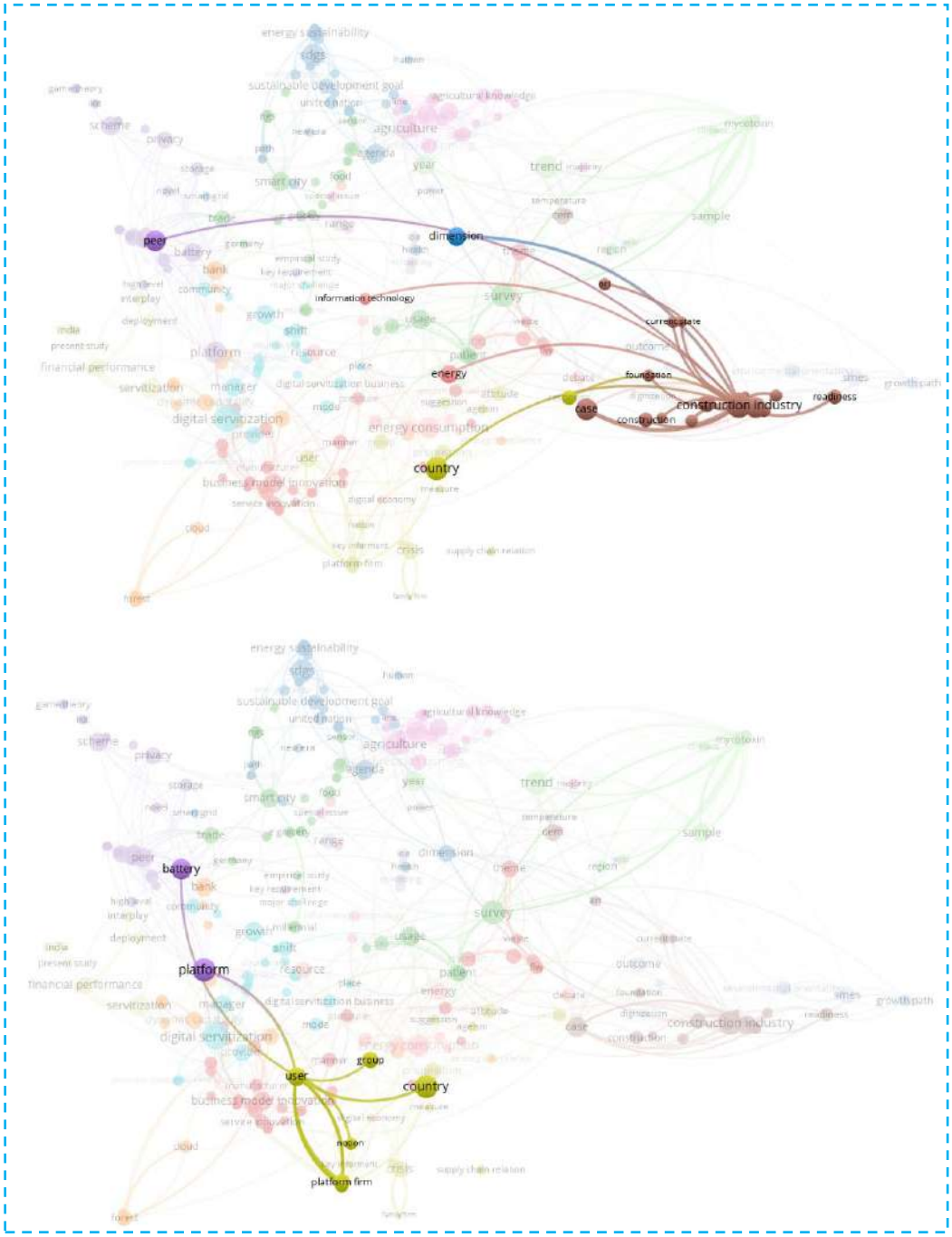


Figure 8 *Highlighting the gap in literature documents - Source: Author*

2.3 Digital Transformation

With regard to the term digital transformation, there was also another initial research conducted in 2018, using the Institute for Scientific Information – Web of Science (ISI) database by a research team that is led by the same Leader Joao Reis and a team of three Portuguese researchers, and they started with the inclusion criteria by using the "Digital Transformation" term in the topic (title, abstract and keywords), with another limitation of English articles and conferences proceedings. The exclusion process of this preliminary research resulted in a total of 206 academic articles from the ISI database (Reis, Amorim, Melão, & Matos, 2018).

This review highlighted that although the number of papers on Digital Transformation grew over time, it was only after 2014 that their numbers increased remarkably. In 2016, 45% of the total number of articles is journal articles and 55% are conference papers, calling attention to a high value for conference proceedings. The United States of America, Germany, and the Popular Republic of China contributed the most to these publications, due to o the adoption of new technologies across the main sectors of activity (Reis, Amorim, Melão, & Matos, 2018).

A complementary step to improve this review process, numerous filters were added to reject irrelevant publications and save time, utilizing the Clarivate Analytics - Web of Science database, which was last revised in April 2022, and to justify the choice of a given type of article over others. The term of Digital Transformation (DT) is found 28,124 times in all fields, and through the exact same process of tackling "Digitalization" terminology, with inclusion to the same criterion of tackling English highly cited papers during the years from 2018 till 2022, The review included 130 articles.

Table 03. Systematic literature review process – DT - WOS last reviewed April 25, 2022

Web of science database		Documents	Query Link	QR Code for Quick Access
Search term "Digital Transformation"	All fields	28,124	https://www.webofscience.com/wos/woscc/summary/6295c0a9-fb00-43b0-a2c1-acc18e03809e-339141a2/relevance/1	
Language	English	25,932	https://www.webofscience.com/wos/woscc/summary/1b4eedaf-4213-4c57-85b0-68a6a8298c2f-339147bd/relevance/1	
Duration	In the past five years (2018-2022)	13,449	https://www.webofscience.com/wos/woscc/summary/1d8de7e4-7972-40d2-850c-7672764a8d31-33914adb/relevance/1	
Citation	Highly Cited papers	130	https://www.webofscience.com/wos/woscc/summary/b487eadb-ee07-4df3-b114-02b94688862b-33914cc0/relevance/1	

The query link:

https://www.webofscience.com/wos/woscc/summary/b487eadb-ee07-4df3-b114-02b94688862b-33914cc0/relevance/1

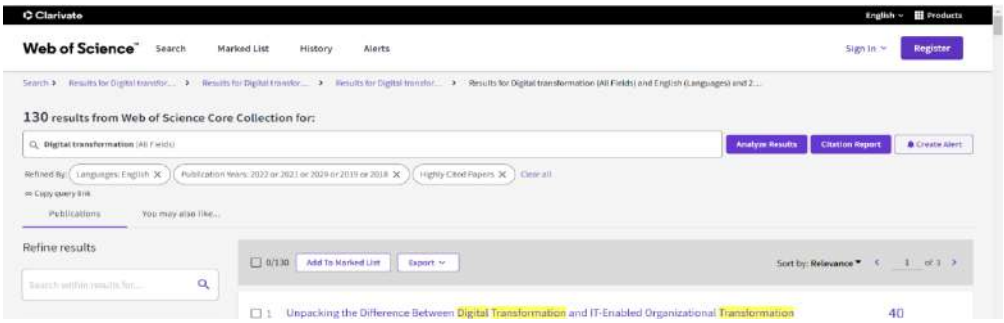


Figure 9 *Snapshot of WOS database review of the term DT in English highly cited papers in the past five years 2018-2022 - Source: Author*

2.3.1 Gaps in Literature of Digital Transformation

The initial search stated that the number of papers and documents conducted on Digital Transformation evolved over time, their numbers did not considerably increase until around 2014. In 2016, journal articles accounted for 45 percent of total articles, while conference papers accounted for 55 percent. The United States of America, Germany, and China contributed the most to these publications, with 21 percent, 19 percent, and 5 percent, respectively.

The adoption of new technology across the major sectors of activities may be the root cause or the origin of these numbers and values in those countries (Reis, Amorim, Melão, & Matos, 2018).

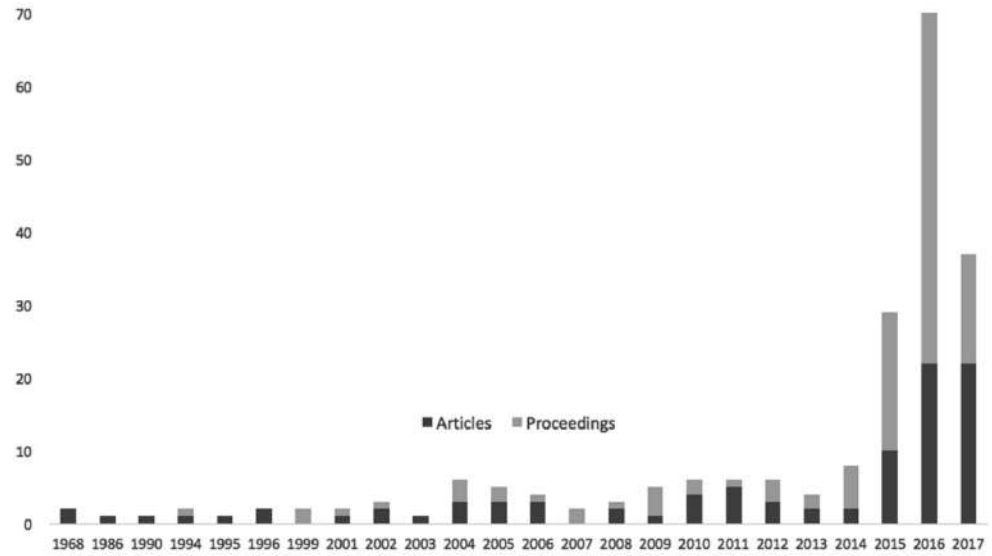


Figure 10 *Publications Distribution – Source: (Reis, Amorim, Melão, & Matos, 2018)*

Researchers also declared that Digital transformation terminology has several definitions mentioned in literature, that are encapsulated in Table 04.

Table 04. Digital Transformation Definitions

Author(s)	Definition
Fitzgerald et al.	Use of modern digital technologies such as social media, mobile, analytics, and embedded devices to enable big business benefits such as improving customer experience, optimizing operations, and developing new business models.
Solis et al.	Realignment of technology and business structures or paradigms, or new investment in them, to better engage digital customers at every touch point in the customer experience lifecycle.
McDonald and Rowsell-Jones	the Digital Transformation goes beyond simply digitising resources, resulting in the creation of value and money from digital assets.
Westerman et al.	The use of technology to dramatically increase the performance or reach of businesses is known as digital transformation.
Stolterman and Fors	The changes that digital technology produces or impacts in all parts of human life are referred to as digital transformation.

Furthermore, Reis and his team claimed that these different definitions for Digital Transformation may be categorized in three specific definite elements: Technological – is founded on the application of emerging digital technologies such as social networking, mobile, analytics, and embedded devices; Organizational – DT necessitates a shift in organizational processes or the development and creation of new business models; and Social – DT is a phenomenon that has an impact on all parts of human life, such as improving customer experience (Reis, Amorim, Melão, & Matos, 2018).

Additionally, they classified the 206 scanned documents into categories of research areas, and it was found that 34% of these documents were about Information systems, 22% tackled business economics, digital enterprise architecture, 8% for education aspects, technology and training related, 4% regarding Management science, and 1% for the Government research area that focus on public sector transformation.

With the complementary systematic literature review research, we could declare that DT is not just the use of technology to entirely enhance performance or reach of enterprises and is not just all about the adoption of a set of technologies as mentioned according to (Westerman, Calméjane, Bonnet, Ferraris, & McAfee, 2011) rather, it is a continuous process of change and renewal and an essential shift or a transition in culture, supported, aided, and facilitated by technology (Davenport & Redman, 2020; NBS, 2018).

And if Digitization is about converting all information type into digital language, Digitalization is where businesses make digital information work for them by adding value to their operations. Then transformation is wider shell that also includes change in culture to improve and enhance an enterprise. In other words, Digitization and Digitalization are pre-requisites to Digital transformation (Ogbevoen, 2020; Syed, 2018).

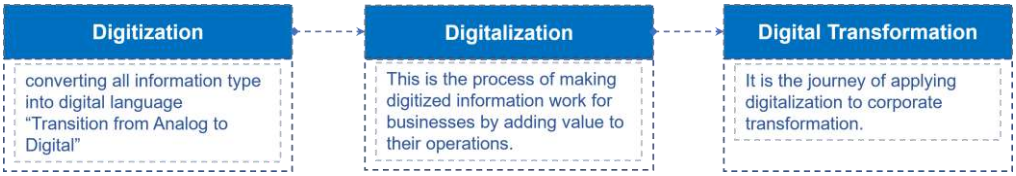


Figure 11 *Transformation flow process – Source: Author based on compiled references.*

Moreover, our systematic review proclaim that to stay competitive in the business and economic environment, this requires new strategies and practices, that follows certain type of digital transformation approaches.

DT Types and Approaches

Digital transformation is not a single grand entity. Frequently corporations and partnerships are focused entirely on organizational transformation and overlook the fact there are four types of digital transformations (Davenport & Redman, 2020).

1. Process Transformation

This type of Transformation requires an end-to-end mindset, a rethinking of ways to meet customer needs, logical smooth connection of work activities, from data, analytics, APIs, and machine learning to other technologies, much focus within the collective environment has been on new ways to reinvent business processes to lower costs, improve quality, or reduce cycle times. Examples of successful process transformation include companies like Domino's Pizza, where today customers can order from any device. They've totally reimagined the food ordering process. This innovation has helped them to overtake their rival competing Pizza Hut concerning sales. Other companies have implemented robotic process automation to simplify their back-office processes, including legal and accounting as examples. Process transformation can create extraordinary values in a company (Davenport & Redman, 2020).

2. Business Model Transformation

Process transformation focuses on definite fixed areas of the business. Business model transformations aim at the foundational building blocks of how value is delivered in a specific industry. Basically, companies are using digital transformation to change traditional business models. Examples of this type of reinvention of the business model include Netflix's redesign of video distribution and Apple's reinvention of music delivery: iTunes (Davenport & Redman, 2020).

3. Domain Transformation

A prominent example of how domain transformation works is the online mega-retailer, Amazon. It marched into a new market domain with the launch of Amazon Web Services (AWS) and is currently the largest cloud computing/infrastructure service in a formerly owned field by giants such as IBM and Microsoft. AWS is a clear example of how new technologies redefine products and services, blurring industry boundaries and creating entirely new

sets of non-traditional competitors. Domain transformation currently offers one of the most significant opportunities for company growth (Davenport & Redman, 2020).

4. Cultural / Organizational Transformation

In this domain we include leadership, teamwork, courage, emotional intelligence, and other aspects of change management. A reconsideration of organization mindsets, processes, talent, and capabilities for the digital world is always needed to achieve long-term digital transformation for any industry. The most successful corporations notice digital transformation requires a flexible workflow, a decentralized decision-making process, a bias toward testing and learning, and a greater reliance on different business ecosystems. One of the best examples of this cultural/organizational transformation is the consumer credit agency Experian. It was able to change its organization by instilling collaboration and agile development into its workflows. Additionally, it spearheaded a fundamental shift in employee focus from equipment to data throughout the company (Davenport & Redman, 2020).

And all these types might follow certain approach or a strategy from the following DT approaches (Li , 2020).

1. Innovating by experimenting and waiting for a proof of digital success

This approach is a popular approach that enables businesses to try out many new ideas inexpensively and helps organizations and systems focused on empirical results (Li , 2018). They can be assessed using emerging intelligence from both internal and external sources. If an idea succeeds, scale it up quickly; if it doesn't, move on to something else and you won't lose anything. Such an approach provides opportunity for business executives to experiment, test, and learn, the difficulty with this approach is the exceptional risk of remaining unproductive until your digital transformation catches on.

Since most organizations have a mixture of digital and non-digital solutions, this first approach is usually the first choice for most companies (Li, 2020; Li, 2018).

2. Dynamic sustainable advantages through an evolving portfolio of temporary advantages /Develop an all-inclusive digital strategy

This approach targets and focuses on getting the strategy as complete as possible from the start. It encourages business leaders to focus on short-term decisions and execution, but with the requirement of a robust booming long-term plan and destination in mind. The all-inclusive digital transformation strategy focuses on changing the culture and immediately implementing innovation. The gains from each momentary advantage are frequently minor, but the cumulative effect over time can be enormous. It is usually quite an expensive approach with many dangerous aspects. Businesses with great patience and a greed for risk need only apply (Li, 2020).

3. Radical transformation through incremental approaches - Incremental delivery of digital skill

This approach spotlights on delivering benefits as a company moves toward a potential changing digital destination after identifying an initial target, roadmap, and route. It is accomplished in a succession of small steps, with the high risks appropriately controlled. But as the organization progresses, lessons learned and new inputs are considered, thereby changing the digital goal and sometimes the path to the destination. Therefore, this approach concentrates on delivering a solid yet doable, adaptable strategy that can evolve with industry changes throughout its lifetime (Li, 2020).

To wrap up the previous findings, here is an attempt to explain why a business transformation plan is necessary for any company or organization that aspires and seeks to be on top of the list in its industry.

Figure 12 *Transformation strategy– Source: (Syed, 2018) Edited by: Author*

Figure 12 shows that the first set of gears is significantly larger than the other sets, but all of the gears are operating independently without having any impact on the other gears. As a result, the people, processes, and technology aren't aligned to work together. This is the situation in the majority of businesses and organizations, where the strategy isn't enforced throughout the entire organization to accomplish common goals.

Even though the second set of gears in the middle are smaller than the first set, they are properly aligned, and as a result, they are able to influence one another. This is an illustration of an organization in which the goals and strategies are clearly defined, and they are communicated downward from the top.

The third group of gears is meant to symbolize a digitally changed firm in which each individual process, person, and piece of technology is performing exceptionally well in order to realize the organization's objectives.

In addition, analyzing the full record of the data downloaded from Web of Science (WOS) using VOS-Viewer as previously stated to produce the bibliometric maps in figures 13 and 14.

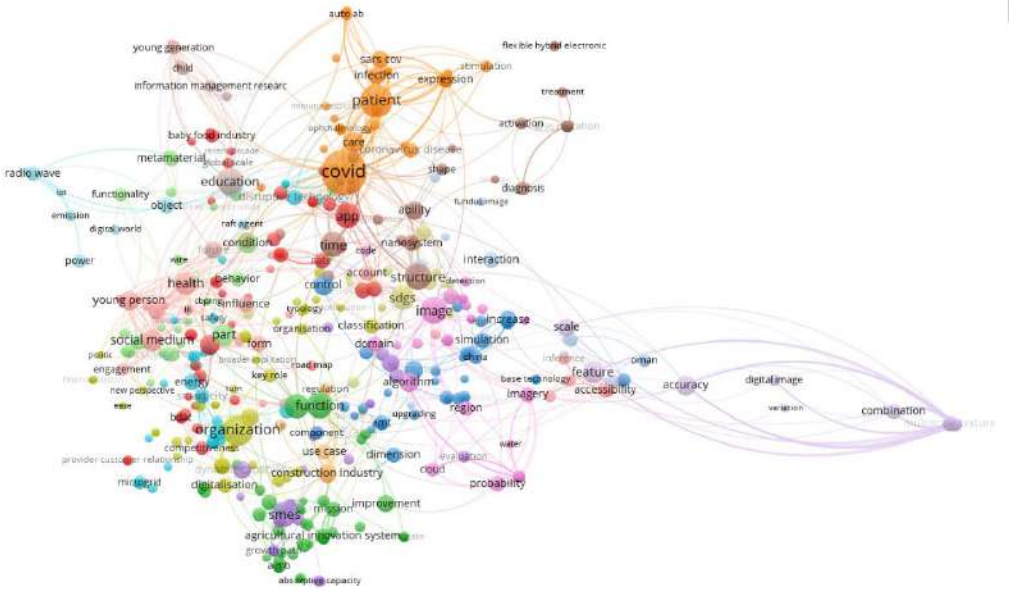


Figure 13 *The bibliometric source mapping of DT based on WOS database highly cited papers during 2018-2022 and analyzed by VOS viewer. Source: Author*

We could claim that there are seven main subject area categories such as health care, economy, education, food industry, energy, computer science, and the agricultural industry, and it is obvious how the academic literature direction deviated to give more attention to the Coronavirus Pandemic after its surprising outbreak strike in 2019. So, let's have a glimpse of what happened since that moment.

2.4 Coronavirus Strike

In early December 2019, the first case of coronavirus (COVID-19) was detected and diagnosed in China (World Health Organization, 2020). The virus was detected all over the world by February 2020. The world found itself facing one of the hardest challenges in history, due to this pandemic that caused the death of over six million people worldwide by March 2022 (Worldometer, 2022).

Thousands of people are still getting infected daily. The Coronavirus affects all aspects and spheres of life. It is a national emergency. By April 2020, about

100 countries, that is nearly half of the world's population, were under lockdown (OECD , 2020).

This health crisis has turned into an extraordinary socio-economic shock all over the world, COVID-19 pandemic illustrated the importance of adapting quickly to dramatic changes, including disruptions to supply chains, time-to-market pressures, and rapidly changing customer expectations. Engineers and technology professionals believe that smart technologies can help people stay safe, healthy during the pandemic, to avoid it, and to provide smooth and secure functions to fight against pandemic diseases such as COVID-19. So, they come out with long-term technological solutions to assist human activities while staying at home during the pandemic. The Internet of Things, Artificial Intelligent, Wireless communication technologies, and 5G networks are just some of the ideas that have been developed (Nafrees, Ponnampalam, Razeeth, Kariapper, & Samsudeen, 2022)

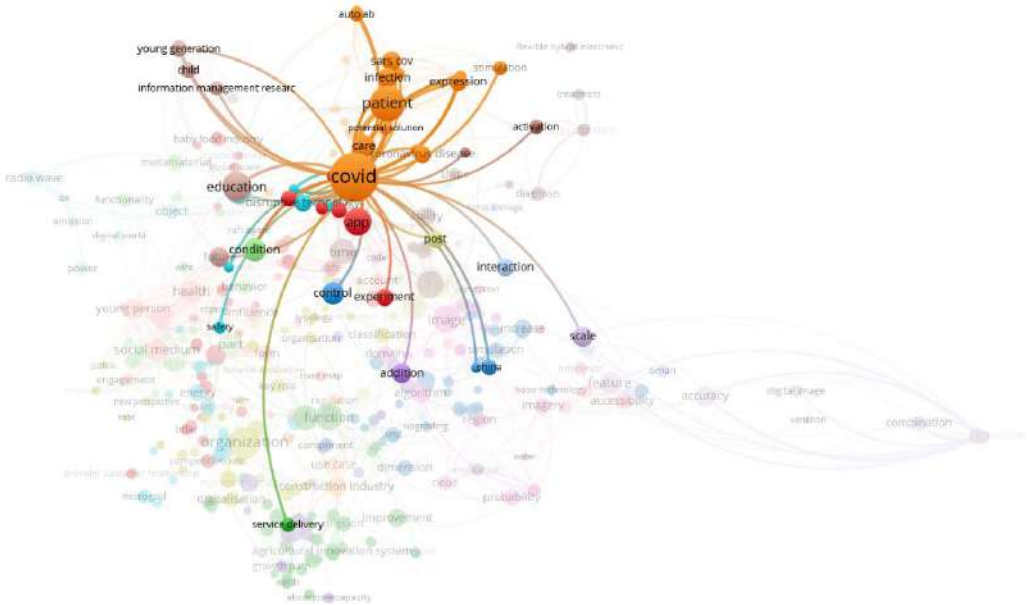


Figure 14 *Scholar publications about DT in the context of Coronavirus pandemic – Source: Author*

Academic publications from all over the world focused more on the relation among the digital transformation, such an unprecedented pandemic, the medical, and the education sectors, or even tackled how these two sectors response or maintain the stability of the workflow in the context of the COVID-19 crisis. As highlighted in figure 15.

Practically, in Egypt, due to the outbreak of the pandemic, the country has witnessed an acceleration of its digital transformation plan. The number of peak hours for internet usage has increased by 99 percent to 15 hours per day from 7 hours per day. Cellular phone internet usage has climbed by 35%, and international calls have increased by 19%. Zoom (3465 percent), Telegram (1100 percent), and YouTube were among the apps that saw a large rise in usage (115 percent) (Bissada, 2021).

This indicates how a health crisis like this works as a catalyst for going digital in all aspects of life, which later reveals social inequality problems, and exposes the dilemma of class discrimination in the society (Nafrees, Ponnampalam, Razeeth, Kariapper, & Samsudeen, 2022; Mendes, 2020; McKinsey & Company, 2020).

Even though, practical wise, Egypt tried to have a digital transformation plan as a response to such an epidemic, there is still a missing gap in academia connecting these terms together, there is still a gap in the professional scale and the question remains; are we ready for such a transformation? Can we transform all our businesses processes into a digital one?

2.5 Bring Things to New Level

This chapter contributes to a better understanding for the assigned terminologies “Digitalization and Digital Transformation DT”. Although these terms are somehow famous among practitioners, they tend to be neglected in academia.

The diagrams extracted from VOS-Viewer prove and support this research problem statement that there is a gap in literature in tackling the relation among the user readiness, technology adoption, use and construction industry which comprises all firms and offices that design and construct houses, office buildings, highways, and bridges, as well as electricians, plumbers, and masons, who are typically involved in the construction of all sorts of structures. This study is unique as no studies have specifically addressed this gap. The VOS-Viewer results also highlighted the rapid focus on the COVID-19 epidemic in literature in the past five years, also the grabbed attention to its role in acceleration of DT and exposing the dilemma of social inequality. So, additional debates, future works could be beneficial targeting relationship among the pandemic, DT, and social discrimination.

After this comparative analysis of both terminologies, it is noticeable that Digitalization is preliminary step towards digital transformation, Digital transformation (DT) is broader than digitalization; more than just applying technology to existing business, it is the capacity to rapidly adapt when required through the smart use of technologies and information, it is about building bridges between IT, business processes, and people capabilities. It is more of a continual process of change and renewal than it is a path leading to a predetermined destination (Clerck, 2017; NBS, 2018).

we get to know that it is valuable for academics to pay more attention to Digital Transformation. Consequently, in the next chapter we will scan and discuss digital transformation initiatives globally and locally to come up with the lessons learned and values of adopting such a process in different fields and specifically in architecture.

	Digitalization		Digital Transformation	
Database/ year	Initial research/systematic Literature Review 2020	Complementary phase covering Literature from 2018-2022	Initial research/systematic Literature Review 2018	Complementary phase covering Literature from 2018-2022
	Scopus citation Database	Web of Science Database	Institute for Scientific Information ISI	Web of Science Database
Inclusion criteria	• Journal Articles • Language: English	• Language: English • In the past five years 2018-2022 • Highly cited papers	• Topic (Title, abstract, and keywords) • Journal Articles, and conference proceedings	• Language: English • In the past five years 2018-2022 • Highly cited papers
Main Definitions	Digitalization means transformation of all information types (text, sound, visuals, video, and other data from various sources) into the digital language	digitalization is the use of digital technologies and digitized data to enable or facilitate processes of any sort of business	Digital Transformation goes beyond simply digitizing resources, resulting in the creation of value and money from digital assets.	DT is not just the use of technology to entirely enhance performance. rather, it is an essential transition in culture, aided, and facilitated by technology.
Documents main subject areas	• Business Management and accounting • Social science • Economics, econometrics, and finances • Computer science • Environmental sciences • Art and humanities • Energy •Engineering • Earth and planetary science • Decision science	• Economics • Business management • the agriculture knowledge • Engineering - construction industry • Energy track • Environmental science • Humanities	• Information systems • Business economics • Education • Management Science • Government – Public sector transformation	• Health care • Economy • Education • Food industry • Energy • Computer science • the agricultural industry

Figure 15 *Summary of the Comparative systematic reviews of both terminologies – Source: Author*

Chapter 03: Digital Transformation Initiatives

3.1 Introduction

The speedy rapid growth of digital technologies has enabled significant profound changes in plans, strategies, and operations across a wide range of sectors around the world. The modern-day effort to survive the existential threat of digital disruption has been entitled as "digital transformation."

The Architecture, Engineering and Construction (AEC) business industry is one of the sectors that is witnessing a significant huge shift from conventional traditional labor-intensive methods to automation using digital technologies and has played a significant role in this transformation revolution (Wang, Wang, Sepasgozar, & Zlatanova, 2020). And these technologies have been proven to be helpful in the Architecture, Engineering and Construction industry due to their several benefits to project stakeholders, such as enhanced visualization, better data sharing, reduction in building waste, increased productivity, sustainable performance, and safety improvement (Manzoor, Othman, & Pomares, 2021).

This study that has been done by Manzoor and his team has reached findings regarding digital technologies in the AEC industry under one umbrella. The United States obviously has the most advanced research in the topic of digital technologies, followed by China, Spain, the United Kingdom, and Australia. BIM, construction management, civil engineering, photogrammetry, construction, AR, information technology, and automation are among the primary topics of the author's keyword co-occurrence. Furthermore, of all other digital technologies in the AEC business, BIM is the most emerging. In terms of digital technologies, BIM–blockchain integration is viewed as the most promising new technology in the AEC business (Manzoor, Othman, & Pomares, 2021).

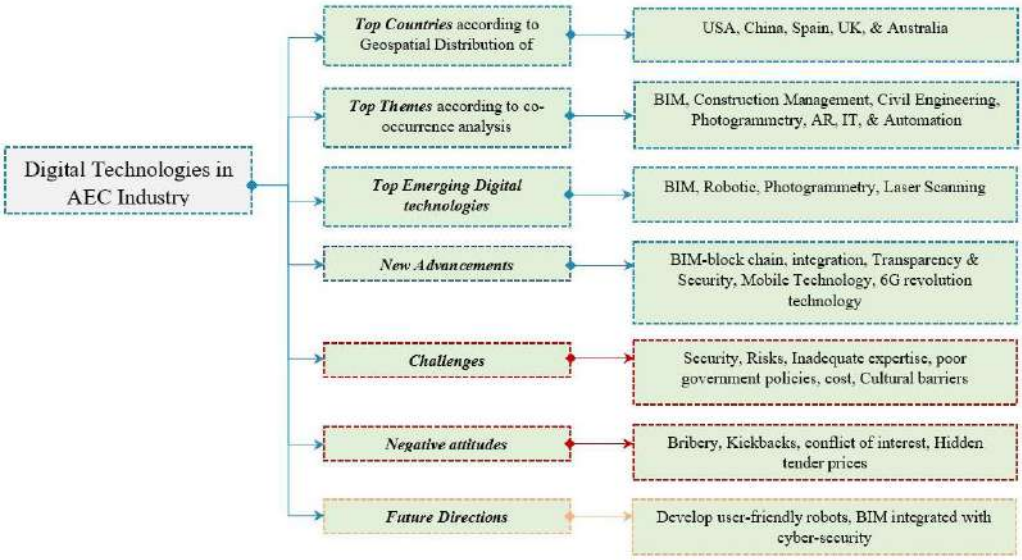


Figure 16 *Digital technologies in AEC industry – Source: (Manzoor, Othman, & Pomares, 2021)Edited by Author*

As a result, this chapter aims to examine several global and local initiatives that used various approaches to digital technology adoption in various fields, particularly architecture. A comparative analysis is followed to approach digital transformation initiatives in several contexts, describing each experience on its own, understanding the different methodologies and tracks of adopting technologies, understanding the lessons learned from each, highlighting the pros and cons of each scenario as well.

After the brief quick Internet search of Digital Transformation initiative, it was clear that this kind of information was unachievable to be obtained just from secondary resources. For that reason, we approach global cases through secondary resources, but for the local cases we approach it through primary resources of comprehensive organized open-ended interviews with office' head/CEOs, and employees, considering the possibilities of reaching out to their key experts with in-depth understanding of Digital Transformation-related topics.

3.2 Global Initiatives

(A) Zagreb, Croatia (Furjan, Pupek, & Pihir, 2020)

With the goal to explore Digital Transformation initiatives, regardless the complexity of such projects, initial research was conducted in Zagreb, published in Business systems research journal, and focused on companies, which are implementing and integrating digital technology into their own business or into the business of their customers.

This research followed the exploratory multi-case studies methodology proposed by Yin (Yin, 2014), with data collection proposed by Eisenhardt (Eisenhardt, 1989) , set as a combination of interviews and questionnaires most appropriate for examining real-life initiatives, to broaden the reach and see a larger picture, which enabled us to obtain data needed for the planned research.

After verifying that the project fits and meets the improvement and technology-related requirements outlined previously for evaluating it as a Digital Transformation initiative, this study includes 6 Digital Transformation initiatives in Croatia gathered through interviews and questionnaire responses. Experts were chosen based on their experience, and only six cases were chosen as Digital Transformation initiatives out of ten interviews/experts. Each interview lasted 30-60 minutes, and the questionnaire was completed via e-mail a week following the initial interview. Word and Excel spreadsheets were used to code the information gained.

According to the theoretical background the research model was developed combining background factors that form the context of Digital Transformation efforts, drivers of Digital Transformation that are proposed by (Hrustek, Kutnjak, & Tomičić Furjan, 2019) and related knowledge and core capabilities of Digital Transformation experts who are supporting or leading Digital Transformation initiative. To answer the research questions, A questionnaire was created with a collection of semi-structured questions. The questionnaire was sent to the expert after the initial preliminary

interview, which determined if the Digital Transformation initiative is a valid Digital Transformation project. The experts were asked to complete one valid Digital Transformation project questionnaire. The questionnaire was divided into four sections: Part one is the background information about the Digital Transformation expert; Part two is the information about a successful Digital Transformation initiative (project); Part three is the evaluation of business and technological concepts within the Digital Transformation initiative; and Part four the demographics of the organization where the project took place.

Researchers found that, the digital transformation initiative in organization A was essentially focused on replacing number of the existing applications, which based on their description have reached “End of Life” maturity phase, however, it also included introducing new technological aspects to optimize End-to-End processes and the compliance with industry standards guidelines is being monitored. This organization project resulted in three main elements: the end-users' aspect or concept of services and Internal users' services are being simplified, enhance, and upgrade the IT tools needed for executing and running the operational activities at the desired level; for instance, Robotics process automation RPA. The research team came up with success factors regarding this process-oriented digital transformation initiative, which were addressing project sponsorship, adequate financial supplies, and resources, outsourcing with necessary know-how that was not available internally, and employee motivation were all driven by an internal assessment of organizational innovation needs in the form of ensuring proper cost and time efficient IT support in the long run.

The initiative in organization B aimed to introduce warehouse process robotization, as a response to the raised competition and the increased demand, and it was pushed and supported by digital technologies and organizational goals of workload optimization. To locate, pick up, and enable delivery of products, the organization incorporated and involved the use of autonomous robotic industrial vehicles that may operate in three shifts based

on tasks assigned by employees or through WMS (warehouse management system) more efficiently. Key crucial elements and factors of success in this process-oriented initiative were related to the processes management support, and modern technologies acceptance and readiness of employees who lack the time, capabilities, motivation, or fear of being replaced to adjust to the technological changes.

Regarding the third case, organization C initiative, it was a proposal for a new IT service to prevent crimes in public sector organizations to protect the Croatian citizens. The need for conformity with operating industry standards was the key motivating force behind this endeavor. The success of this transformation project mainly depends on the financial means that are available, and the legal frame regulations internally in the organization.

The fourth scenario in organization D, which is a provider of on-demand transportation. Organization D was obliged to rethink and reorganize its business strategy to enable on-demand services with digital technology due to disruptive rivals and competitors. The availability of financial resources was once again a major success factor, but the organization recognized that to remain in their turbulent unstable self-regulating market, a fundamental transformation restructuring was the only option. The key driving factors were identified from the customer perspective, notably a drop in demand, disruptive competition that was stealing clients, and an obsolete business strategy.

The fifth initiative of Organization E, Organization E launched its Digital Transformation program with two main goals in mind: offering smart mobile payments and establishing new card payment services. Client orientation was the driving force in this case, and the benefits of the Digital Transformation project were an increase in customer base and, indirectly, greater income from payment transactions. The vision and support of management, as well as staff competencies and project management efficiency, were critical and essential in this project.

Last but not least, Organization F. By implementing workflow management for a complex business process and normalizing and standardizing procedures and rules, the project in organization F enabled the shift to a Digital Transformation of design completion, a successful delivery, submitting and validating client documentation for issuing certificates in the public sector. As a result, the process duration was shortened, unified control assurance of the issuing process was implemented, and cost reductions for all process actors were amplified. Several major influencing elements were found throughout implementation, including senior management engagement, a focus on achieving projected objectives, the competencies of project team members, the availability of financial resources, and technologies. The project was motivated by the need to improve the efficiency of the operational business model and was based on customer expectations.

Digital Transformation Initiative	Success Leading Factors
Organization A	Project sponsorship/ adequate financial supplies, Employees' motivation and Internal assessment of organizational innovation needs in the form of ensuring proper cost and time efficient IT support in the long run.
Organization B	The processes management support, and modern technologies adapting of employees who lack the time, capabilities, motivation, or fear of being replaced to adjust to the technological changes.
Organization C	The financial means that are available, and the legal frame regulations internally in the organization.
Organization D	Financial resources
Organization E	The vision and support of management, as well as staff competencies and project management efficiency
Organization F	Senior management engagement, a focus on achieving projected objectives, the competencies of project team members, the availability of financial resources, and technologies.

Figure 17 *DT initiatives in Croatia success leading factors - Source: Author*

Wrapping up these Digital Transformation initiatives leading success factors, mainly have been found in three majors: financial resources, senior management support, and employee competencies. The majority of drivers mentioned by Digital Transformation specialists can be classified as organizational, customer, and technology driven efforts, with the order corresponding to the frequency of driver appearances. The intended outcomes of Digital Transformation initiatives show primarily business-related goals of process improvement, new product, or service introduction, responding to disruptive competition (organizational), ensuring proper technology support for realizing new business models (technological), and finally customer value goals (customer orientation). Due to the strong commercial focus of the participating examinees in this study, it is not surprising that business orientation is the driving factor in the examined situations.

(B) Digital Transformation on Architecture and Engineering Firms' Processes and Organizational Structures – The Cases of Italy & Canada (Talamo & Bonanomi, 2020)

Tackling other case studies, for the purpose of this study, Since the adoption of digital technology in the architecture, engineering, and construction (AEC) sector is accelerating, and there is reason to believe that this will lead to increases in productivity and competitiveness within the sector, as well as in the effectiveness of processes and the quality of products. Both academics and industry professionals are already investing a significant amount of time and energy to the promotion of the use of digital technology. To be able to reap the full benefits of digitalization, one must, however, adopt a more holistic approach that takes into account not only technology but also processes and organizations. It is necessary to do research into the interactions and effects of digital transformation on the processes and organizational models utilized by the majority of projects and businesses. Because of this, there is a pressing need to investigate new processes and organizational structures, as well as the

influence that these shifts will have on the physical layout of work, as well as the socio-technical environment that will be necessary to enable these shifts.

This research utilized a mixed-method case-study methodology to investigate this topic. One of the A/E firms is an architectural and engineering firm headquartered in Italy that has less than 250 employees and one in Canada more than or equal to 250 employees. Both firms were analyzed using an extended case-study format. Specifically, the case study of the Italian company has meant understanding in practice the changes that are process oriented as well as the new forms of process that are related with digitalization. The case study of the Canadian company has rather been analyzed to identify how the adoption of digital technologies affects the existing organizational setting and how this one can be reconfigured to facilitate the achievement of the full benefits of digitalization. This analysis was done in order to determine how the adoption of digital technologies affects the existing organizational setting.

The research team followed a methodology in both case studies, the data collecting, analysis, and representation processes were carried out by focusing on three distinct but complimentary states of change:

1. 'As-is' condition. This step entailed gathering data, analyzing it, and visualizing the traditional design process and existing organizational structure.

2. The state of 'transition.' This phase includes data gathering, analysis, and representation of the design process and organizational structure in existence when digital technologies were initially adopted.

3. The 'to-be' state This step entailed gathering data, analyzing it, and visualizing the desired digital design process and organizational structure in order to reap the maximum benefits of digital transformation.

I. Italy

Process-Oriented Transformation in the Italian Firm

The 'as-is' condition of the design process has been characterized by extensive document analysis, with the firm's quality management system (QMS) serving as the major data source. Second, the 'transition' condition of the design process was investigated through observation, interviews, document analysis, and process mapping of an Italian firm's BIM pilot project. Finally, the 'to-be' state of the design process has been imagined based on a survey of the literature and international standards on BIM and digital design processes. To summarize, the three design process states ('as-is,' 'transition,' and 'to-be') have been cross-compared to discover differences. This final phase resulted in the identification of process-oriented improvements brought about by the use of digital technology within the firm, as well as those that still need to be adopted in order to attain the full benefits of digitalization.

Data gathering and analysis of the Italian firm's case study resulted in the identification of process-oriented improvements brought about by the use of digital technologies within the firm (Summarized in Table 5), as well as those that remain to be implemented in order to reap the full benefits of digitalization (Summarized in Table 6).

Some organizational and technological changes have been recognized as a result of the multidimensional character of the changes connected with digitalization. These observations have been classified according to Poirier et al. basic dimensions of digitalization (Talamo & Bonanomi, 2020; Poirier, Staub-French, & Forgues, 2015). In reality, important components of digitalization, according to her concept, fall into three categories: process, organization, and technology.

Table 5. Changes within the Italian enterprise brought about by the introduction of digital technology (Employer's information requirements, BIM execution plan)

Process	Organization	Technology
Enhanced information sharing between the architectural (A) and engineering (E) teams, as well as between the A and rendering (R) teams	Marketing and business prospects have grown.	Implementation of new hardware, software, and tools
Collaboration between the A and E teams has improved.	Added responsibilities and new roles	
The A and E teams work together to make decisions.	A and E teams have learned BIM skills and abilities.	
The A and E deliverables have been improved in terms of consistency.		
Reduction in the amount of time spent coordinating (exchanging files) by the A and R teams		
A decline in the number of files produced by the A and E departments		

Table 6. Changes must be made in order to earn the full benefits of digital transformation

Process	Organization	Technology
BIM requirements are agreed upon in advance with the client.	Every business unit (BU) involved in a project will have gained BIM knowledge and capabilities	Establishment of the BIM environment and associated procedures (graphic standard, BIM libraries, etc.).
Initial identification of the roles and duties of project participants		
BIM is used throughout the design process.		
All of the business units (BU) in a project should use BIM.		
a preliminary assessment of project team BIM abilities and knowledge		

II. Canada

Organizational Changes in the Canadian Firm

As a first stage, the "as-is" condition of the company's organizational structure has been identified by an in-depth document analysis. The company's human resources (HR) database, which included all of the supervisor–employee couples, was used as the major data source for this research. Secondly, the 'transition' state of the organizational structure has been defined by distributing a questionnaire to employees, which asked them to identify the peers they referred to for advice and help about digital technologies and processes. The results of this questionnaire were used to determine the organizational structure in its 'transition' state. Following the collection of the data, it was decided to conduct an analysis utilizing social network theory. Finally, the "to-be state" of the organizational structure has been envisioned by conducting interviews with the company's senior management and doing a literature analysis on new business models that enhance digital knowledge management. Both of these methods were used to gather information.

Through the case study of the Canadian company and its data collection and analysis, it has been possible to see the organizational changes that the company made when it started using digital technologies, as well as the changes that still need to be made for the company to get the most out of digitalization.

In particular, the information gathered from the questionnaire given to the company's employees has helped find a network of professionals from different fields who are seen by their peers as informal "go-to" people for advice and help with digital technologies and processes. Even though these employees were very important to the company because they helped other people get their work done, the existing organizational structure (the "as-is" state) did not recognize them. So, in addition to the formal roles and responsibilities set by the organization's structure, there were also informal roles and relationships in place for getting advice and help with digital

technologies and processes. This was when the organization of the company was "in transition."

Because this "transition" state makes it hard to get work done, the firm's top management has been asked to consider a reorganization that would define the "to-be" state of the organization. This "to-be" state meant that this informal network of "go-to" people was officially recognized by making a support group for digital technologies and processes at the firm level. So, there are now new roles, responsibilities, and relationships assigned in the Team Canvas Model of the organization.

3.3 Local Initiatives of Cairo, Egypt

3.3.1 Introduction

Egypt vision 2030

According to Egypt Vision 2030 in alignment with UN SDGs, the government is transforming to Digitalization, the Egyptian government investments USD 1.9B, to develop informational digital infrastructure, create technological innovation pools and established Hi Tech industries in the economic zone. The Digital technologies represent an unprecedented opportunity for the government to reinvent and improve itself. The Egyptian government is working as a participatory digital government to implement and establish financial inclusion and FinTech Apps towards secured cashless, paperless digital knowledge society (Ghoneim, 2021; MPED, 2020).

The Egyptian government is implementing several investments, capacity-building and training programs, digital government service reforms, and infrastructure enhancements as part of its ICT 2030 agenda. The strategy asks for the launch of new projects to increase the ICT sector's contribution to Egypt's economic growth. A plan for the digital transformation of core government services in the areas of education, healthcare, construction, and government services is also included in the strategy.

The Ministry of Communication and Information Technology (MCIT) has launched the "Our Future is Digital" initiative, which aims to train 100,000 young Egyptians in high-demand ICT skills such as website design, data analysis, and digital marketing. In addition, the ministry created the "Our Digital Opportunity" initiative in 2020 to engage SMEs in the digital transformation process. The ministry's Digital Egypt Project intends to construct and distribute fiber-optic cable connections to all government agencies. This process has been completed in 5,300 government buildings in Egypt, with a total expenditure of 6 billion Egyptian Pounds (about $375 million) to connect 32,000 institutions and facilities (Bissada, 2021).

As previously stated, such a topic is unachievable to be derived just from secondary published resources, so that, 5 Egyptian DT initiatives are tackled. Tackling local digital transformation initiatives, data is collected “primary resources” using qualitative research technique of five open-ended interviews. This part method’ justification is to describe different local DT initiatives and explore pros and cons of each journey. The open-ended interview is designed to explore the initiatives’ natures/types, approaches, strategies, and outcomes.

Experts and specialists are contacted and interviewed using face-to-face and online interviews. Each interview has lasted for 15-30 minutes. The format of the interview consists primarily of the following open-ended questions in the following order:

Q1: What is the first thing that comes to your mind after hearing the term DT?

Q2: When have you established/joined the office?

Q3: What digital technologies do you adopt in the office?

Q4: What is the motivation behind choosing such tools?

Q5: What is the Approach/Strategy of adopting such tools in your transformation journey?

Q6: Was it easy to integrate it within the processes?

Q7: What are the core differences before and after adopting and integrating these tools into business? Differences regarding "Cost/profit, Time, Employees readiness and acceptance, Collaboration internally and externally and with the clients"

As mentioned earlier, the open questions are subjected to a thematic analysis (Bernard, 2011; Guest, MacQueen, & Namey, 2012). Finding patterns in the responses and performing analysis on them together with the questionnaire results in chapter 06.

3.3.2 Thematic Pattern

Starting the interviews with an icebreaker, asking the interviewees about their perception of what DT is. Several perceptions have been gathered. Interviewee A (27 years old who has his own business "a design office" and works also as a design architect to an employer in another office both at the same time), interviewee B (44 years old architectural office owner and head, a business owner who works as a university assistant professor as well), interviewee D (26 years old Landscape architect), and interviewee E (27 years old urban designer who also works in a fabrication lab) have responded that they sees DT as the progress and the improvement of business utilizing up-to-date technological software and tools. While interviewee C (Early forties project lead, Digital Fabrication Laboratory (Fab-Lab) head, and a university associate professor) has claimed that the first thing comes to mind is the Egyptian vision of DT, the ICT 2030 agenda.

Speaking about different technological software and tools adopted in these initiatives, interviewees A, B, & D have declared that their offices started at first by using the traditional digital software such as: BIM, Cloud computing,

CAD, Rhino plus grasshopper, Revit architecture, ArcGIS, 3ds-studio max, sketch up, and Photoshop and some mobile applications.

Moreover, interviewee A & B highlighted the role of the VR glasses in their DT journey. Interviewee A has clarified that the team in the office have been doing market research, searching for a differentiator and they have got to choose the VR. Both interviewees A & B have declared that they have started using the VR as a sketching, designing and presentation for clients' tool in corporation with Rhino plus Grasshopper visual programming.

However, interviewee D has highlighted a software called Land F/X as one of the important software the office adopts and utilizes during their DT journey. She has claimed that it works as a Lister that could save a lot of time searching for landscape elements and description on auto CAD.

Interviewee C & E have had another perspective of tools adopted, they have mentioned the ordinary manual fabrication tools, in collaboration with a Laser cutter, a CNC machine, three 3D-printing machines, and They also have mentioned that they have attached different simulation machines, Virtual Reality VR-glasses and scanners as well. However, interviewee C has claimed that these tools are used just for presenting a model, but she aims to change this in future by train the employees as well as trainee to use it for thinking in the design processes, for instance, checking structure joints by fabrication. In the near future, the team plans to buy a Robotic arm with different nozzles that could print concrete/clay parts, it could also drill holes. The interviewee states that the robotic arm would be an extraordinary move and transformation to the Fab-Lab.

The vast majority of interviewees have claimed that the approach they follow in adopting these new tools could be defined as process transformations following experimental approach, innovating by experiment.

Regarding the acceptance, the vast majority have claimed that new tools received acceptance either from business owners or the employees.

Interviewee A have said that he has proposed a trial to his employer of using VR glasses in the design process as a sketching tool and integrate it with the whole package presenting and delivering to the client. It has been highly accepted and welcomed. As a result, the interviewee has integrated the VR glasses in two projects, and he is working on a third project in the time of writing this thesis.

Interviewee B, C & E have claimed that the acceptance and excitement of employees towards trying and adopting new tools in a core success leading factor to the DT initiatives journey. Interviewees B & C also highlighted the importance of employees' training sessions such as the Training of Trainers (TOT).

Interviewees A, B & C have stressed on the importance that the senior management have clear visions towards the approached goal. On the other hand, interviewee D has stated that the business owner and senior management in the office try to have a clear strategy f adopting these tools, a deep R&D is followed before adopting tools but in the contrary no pre-readiness assessments for employees take place.

Furthermore, exploring and investigating the core challenges that these initiatives face, interviewees A & B have mentioned the lack of time to train more employees to use the VR glasses as a design tool in parallel timeline of the office normal daily workflow.

Interviewee A has added that core differences of projects before and after integrating the VR glasses could be the cost as it costs the client almost two thirds of the project total cost if he wants to have the project presented with the VR glasses, and regarding the time it has been stated that preparing a VR presentation takes time so to decrease the whole process time they use other rendering tools such as unreal engine for extended reality in the pre-requisites processes that are faster and gives satisfactory results

It has been declared by interviewees C & E that the financial resources, administrative issues, the internet connection, and its speed as most of the work is done on the cloud, the place is other thing that Fab-Lab considers as a challenge, so they work in a temporary place until they could have another permanent larger space that fit the tools they have as well as an attached outdoor area that they could apply 1:1 scale models.

Ending this interview with a question regarding the profits, benefits, and gains in the contrary with the huge cost the pay for adopting such tools, interviewees A, C & E have claimed that they have been witnessing profits from the transformation, they have claimed that they are on their way to get more benefits, interviewees C & E have added that they are building their business model and they are on track to be a consultancy unit to have more clients and profit out of this laboratory initiative, as there is a few fab-labs in education but none in professional life which is a differentiator and is clearly visible online and offline to the market.

While on the contrary interviewee B has declared that he is expecting not seeing a profit before 5 years, however such a tool like the VR glasses is an "Edge of Design" as quoted by him.

These Egyptian SME initiatives are examples of how the speed of change of technology is accelerating in extraordinary exponential way, Since Prof. Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, announced Industry 4.0, he is convinced that AI, Big Data Analytics, Quantum Computing, 5G, IoT, Robotics, VR, Drones, Nano Tech, Bio Tech, 3D-Printing, and Machine Learning are radically and fundamentally changing the way we live, work, and relate to one another (Ghoneim, 2021).

3.4 Summary

ln aims to investigate existing digital transformation projects in the real world and build a research foundation for subsequent studies in this area. By making use of a strategy based on many cases studies, we gathered data from secondary and primary resources. According to the results of this chapter, there is a clear aspect that financial resources, senior management support, and employee competencies are success leading factors to any DT initiative, on the other hand, the results of this chapter reveal a pressing requirement to improve the level of collaboration that exists between the project participants and the owner or customer of the project from the very beginning phases of the design process onward. In keeping with this attitude, it became clear that there was a need for the owner to be more involved and active in defining and sharing with the interested parties the needs for the project from the very beginning of the process. In addition, the relationships, roles, and responsibilities within and between companies need to be clearly defined in order to facilitate the setting up of a work environment that is conducive to digital innovation and that aims to enhance a dynamic network of teams. This is necessary in order to facilitate the setting up of a work environment that can facilitate the setting up of a work environment that is conducive to digital innovation.

In addition, there is a requirement to facilitate and deepen integration between the project's participants in order to increase information exchange and performance simulation according to a variety of characteristics, such as embodied energy, and so on. In addition, the preliminary evaluation of the digital skills and capabilities of project participants is another key topic that emerged from the findings of this study. This assessment is advised in order to prevent time and expense overruns, and it is a significant topic in its own right. Last but not least, it became clear that there was a pressing requirement to develop standards and processes that should be disseminated both internally (that is, across companies) and externally (that is, throughout the supply chain).

Chapter 04: Digital Readiness and Technology Acceptance Theories

4.1 Introduction

"TECHNO-READY" is not just in the presence of the necessary digital tools, as previously stated in chapter one, but what mostly important is the readiness of the user. The workforce's acceptance and attitude toward using such tools is more significant than the tool's availability (Son & Han, 2011).

The missing ring in the previously discussed case studies is that organizations, and companies went through the journey of transformation without taking a step beyond and question readiness of employees, their acceptance to adopted technologies, how they perceive usefulness of such technology and how they intend to use it. There is no readiness assessment carried on.

From the previous two chapters' outcomes, and summaries we get to know that this study is unique as no studies have specifically addressed the relation between Digital transformation and organizational readiness nor human-being readiness or technology acceptance.

To overcome the existing research gap of the missing ring that has emerged as a promising research trend and useful reference point in recent years, and since the path to digital transformation starts with a digital readiness assessment of an existing technological infrastructure to determine where the firm is now. This is a critical first stage because the outcome will have a big impact on the rest of the procedure (Son & Han, 2011).

So, this chapter looks at the basic models that have discussed Digital Readiness/Technology Readiness Index (TRI) and Technology Acceptance Model (TAM) theories' scales, reviews the elements and key factors that affect people's digital readiness and willingness to use new technology, creates a combined model, and proposes assessment criteria based on which the questionnaire is designed and made.

4.2 Digital Readiness

Over a decade ago, the Journal of Service Research published the Technology Readiness Index (TRI), a 36-item scale designed to assess people's proclivity to adopt and employ cutting-edge technologies. It has now been employed in a variety of scenarios by researchers in over a dozen nations (Parasuraman, 2000; Son & Han, 2011).

The Digital Readiness Index (DRI) is also known as the Networked Readiness Index or the Technology Index (Bharatula & Murthy, 2020). In the literature, the term "digital readiness" has numerous different connotations. Its leading primary definition is the desire of individuals, companies, and sectors of the business to introduce and utilize emerging and applying digital technologies to maximize the benefits of these innovations, it is also defined by an organization's workforce's preparedness to shift into digitized workflows facilitated by software and technology. The faster employees adopt these developing technologies, the easier and smoother the road to digital transformation will be. In this journey, active labor involvement and participation is crucial.

People's tendency to adopt and employ new technologies is referred to as Technology Readiness (TR). Nowadays, the development of technology-based products and services provides users with both benefits and dissatisfaction due to ineffective product and service usage. As a result, how well-prepared consumers/users are for new technologies is a critical aspect in the diffusion and success of these products and services (Son & Han, 2011).

This theory is a potential idea that might be used by all parties to understand the different processes of people adopting new technologies. The level of readiness of the user is a crucial factor that determines whether or not they will embrace a particular technology (Adiyarta, Napitupulu, Nurdianto, Rahim, & Ahmar, 2018).

According to (Parasuraman, 2000), Technology readiness can be conceived of as a gestalt formed by four personality dimensions: optimism, innovativeness, discomfort, and insecurity. Psychometric scale items, while two elements are thought to be motivators for using new technology, the other two are thought to be inhibitors: Optimism: a favorable positive attitude toward technology. With the use of technology, religion can help people gain more control, flexibility, and productivity in their lives. The urge to be the first to apply new technologies is referred to as innovation. Discomfort: the desire for control and a sense of sadness. Insecurity: a fear of technology based on security and privacy concerns. The construct can be understood as an overall mental state that results from a pattern of mental facilitators and inhibitors that collectively define a person's proclivity to employ new technology.

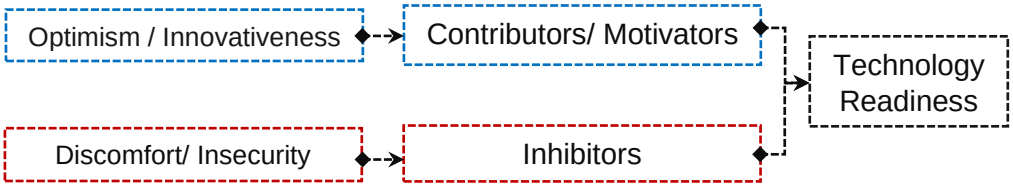


Figure 18 *Technology Readiness Index (TRI) Dimensions. Source: (Parasuraman, 2000) - Edited by: Author*

The influence of a person's personality on their level of technological readiness is seen in figure 18. The Technology Acceptance Index (TRI) is not a measure of people's capability to adopt new technology; rather, it represents people's faith or commitment about new technology. On the basis of this notion, one may postulate about people's general beliefs concerning technology, which would also imply their consumption of technology-based products and services. Users can be classified into one of five groups according to their level of comfort with new technology: explorers, pioneers, sceptics, and paranoid users. The reason that type explorers are so successful in the area of technological preparedness is that, on the one hand, they are innovative and optimistic, and, on the other, they experience relatively little discomfort and insecurity. The mere existence of cutting-edge technology is enough to pique the interest of explorers, who are frequently the first to

experiment with new technologies. Laggards, on the other hand, are the last group to accept the most recent technology since they have a tendency to be inhibitors and tend to be poor in contributory factors. Other types of users, such as pioneers, sceptics, and paranoid users, exhibit a greater variety in how they view technology. The type of pioneers who are strong in optimism and inventiveness, similar to explorers, but who are fragile when it comes to discomfort and insecurity. Skeptics demonstrated a low degree of confidence and innovativeness, in addition to a minor inhibitory level that has to be convinced in advance about the benefits of utilizing technology. Paranoid individuals, on the other hand, have an excessively positive outlook and are enthusiastic about emerging technologies, but at the same time, they experience feelings of unease and insecurity (Adiyarta, Napitupulu, Nurdianto, Rahim, & Ahmar, 2018).

In actual practice, each illustrative dimension will convince a person with high optimism that the new technology will be valuable to boost the productivity of users. Someone who has a high level of innovativeness is eager to participate in experiments involving new technology. The person who has a high level of insecurity has doubts about the ability of new technology to carry out the entire transaction, while the person who is uncomfortable believes that the system was not designed for them, and as a result, they are dissatisfied (Adiyarta, Napitupulu, Nurdianto, Rahim, & Ahmar, 2018).

In fact, readiness also affected by the Self-directed learning aspect, where Self-directed learning (SDL) is the psychological process by which a learner guides himself or herself to gain knowledge and learn how to solve problems, as self-directed learners who learn on their own tend to look for resources on the online learning platform (Long, 1994).

And as stated earlier, the path to digital maturity and excellence is defined by where an organization begins. Understanding the readiness to engage on the digital transformation is thus vital to success. A complete digital readiness evaluation must address three critical essential aspects of process

improvement, which are Culture (People), Process (Processing), and Technology (Philipp, Gerlitz, & Moldabekova, 2020; Philipp, 2020; Ogbevoen, 2020):

1. Culture/people assessment

   The impact of individuals and the culture they practice in the organization must be considered. This will aid the evaluation in defining the functions that various people in the organization play. It will aid in measuring and defining data-driven manufacturing adoption. It will also determine the stage of execution of key efforts such as predictive analytics, machine learning, and so on, if they are currently in place.

2. Process Assessment

   The process reduces or eliminates risk in operations. Understanding the process and adhering to it is thus a vital component of determining digital maturity. It is vital for the success of a digitally enabled workplace to ensure a continuous flow of data and role-based visibility directed by process. This will aid in the development of a cohesive eco-system that allows for data-driven decision making at various levels. Standardizing success metrics and giving appropriate visibility will not only illustrate progress but will also highlight areas of concern. The use of automated and digitally connected procedures instead of manual operations could mean the difference between an organization that is ready for its digital journey and one that is not.

3. Technology Assessment

   Finally, technology is a key paradigm for gauging and evaluating readiness. Technology is essential for automating procedures, making adoption scalable, improving compliance, empowering staff, and increasing visibility. To accept and use the benefits of developing technology, organizations must have a minimal level of technological

maturity. Connected enterprises, for instance, will be a critical necessity for IoT adoption.

As mentioned earlier, A digital readiness assessment of a company's current technology framework is the first step on the path toward a digital transformation. The purpose of this assessment is to determine the current state of the organization. This is a crucial first phase, as the results of this step will primarily determine how the rest of the procedure is carried out. After the preliminary assessment, there will be an activity to identify viable digital talent and gaps in talent. To determine whether or not an organization is capable of adopting digital practices, it is essential to conduct a digital readiness assessment.

An evaluation ought to help gauge the level of readiness to make use of the potential offered by an Internet of Things and machine learning enabled digital transformation. Additionally, it must be able to create areas for prioritization in order to bridge gaps in an operation that is digitally advanced. When the level of digital readiness is understood down to this level of specificity, it is easier to pick and put into action actions that bring the company closer to achieving its goals.

And the first step towards individual readiness is Acceptance.

4.3 Technology Acceptance Theory

Acceptance is generally defined as antagonism toward resistance and an individual's positive choice to use innovation (Simon, 2001). The Technology Acceptance Model (TAM) is yet another behavioral theory that is well renowned for its ability to anticipate user behavior while embracing technology. User acceptance of technology has been a critical topic of study for over two decades now. Although several models have been presented to describe and predict system use, the Technology Acceptance Model has received the greatest attention from the Information Systems community. As

a result, anyone interested in studying user adoption of technology must first comprehend and understand the technology acceptance model (Chuttur, 2009).

With the apparent increase in technology demand in 1970s', and the increase of failures of systems adoptions in several organizations, offices, and firms, the employment of predictive systems became an area of interest for researchers. However, the majority of studies failed to provide credible reliable measurements that could explain and predict system acceptance or rejection (Davis, 1989). Fred Davis, in his PhD at the MIT Sloan School of Management in 1985, proposed the TAM. The Technology acceptance model's primary goal is to offer a foundation for mapping the impact of external events on internal individual components such as beliefs, attitudes, and behavioral intentions. This model was developed to assess these effects by examining certain essential variables proposed by prior research on cognitive and affective computer/new technology tools acceptance (Davis, 1985).

Davis represented in his proposal that the use of a system is a response that can be predicted by user motivation, which is affected directly by a stimulus of the actual system characteristics, features, and capabilities (Davis, 1985).

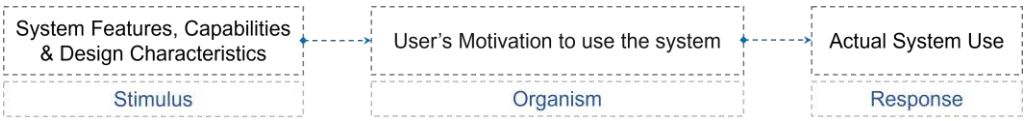


Figure 19 *Conceptual diagram for TAM. Source: (Davis, 1985) – Edited by: Author*

In his proposal, Davis made a suggestion of the aspects that can represent the user's motivation to use the system, could be categorized into three main categories: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and Attitude towards using a system (Davis, 1985), summarized in Figure 20.

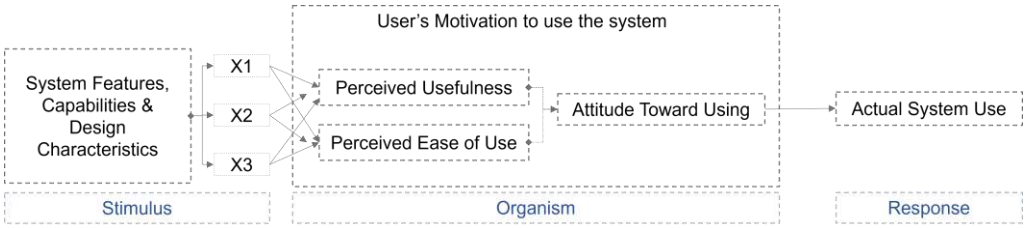


Figure 20 *The Original TAM diagram proposed by Fred Davis. Source: (Davis, 1985) - Edited by: Author*

The primary factors in the TAM model are perceived usefulness and perceived ease of use of technology as a justifiable act in the context of technology users. As a result, perceived usefulness and perceived ease of use have a significant impact on the reasons why people use technology. According to (Davis, 1989), the level of user acceptance will significantly affect the level of information technology (IT) adoption by the user. User acceptability can be predicted based on perceived usefulness and perceived simplicity and ease of use. Also, according to (Davis, 1989), both of these criteria have the potential to explain the behavioral elements of users and have been found to strongly influence user adoption of the technology. These conclusions were validated as well by findings from other investigations and studies.

According to figure 20, that is presented earlier, it is possible to observe that the original TAM model contains five different constructs. these constructs include actual system use, attitude toward using, behavioral intention, perceived usefulness, and perceived ease of use. at first, TAM included the variable of attitude toward using; however, later on, this variable was eliminated from the model because of its ineffectiveness un mediating the connection between user belief and behavioral intention to use. Throughout the course of its evolution, the TAM has become a very popular model for predicting attitudes, aspirations, and behaviors in relation to the utilization of new technology. This model accounts for approximately forty percent of the diversity in people's propensity to make use of information and communication technology. Both beliefs factors are determined by external

variables, such as people's trust, the facilitating condition, social influence, gender, age, etc.

Perceived usefulness (PU) is influenced by Perceived Ease of Use (PEOU), while perceived usefulness also influences perceived ease of use. Even though it has been established beyond a reasonable doubt that perceived usefulness and perceived ease of use are factors that influence behavior intention, the relative strength of these two variables differs depending on which external variable is being considered. The perceived value of something a sense of how easy it is to use attitude towards the behavior intention to engage in the behavior the system itself use.

Perceived usefulness is believed to be the key component that determines action and has better explanatory power than the perceived ease of use. The application of perceived usefulness also has a higher correlation with actual behavior. It is conceivable due to the fact that individuals would prioritize the usefulness of a system or technology when deciding whether or not to utilize it, while the level of comfort associated with utilizing it will be addressed later. In today's day and age, TAM is widely utilized in a variety of sectors to investigate user behavior in the context of using new technology. In practice, TAM could be used to measure the degree to which users have adopted technology (Adiyarta, Napitupulu, Nurdianto, Rahim, & Ahmar, 2018; Venkatesh, Morris, Davis, & Davis, 2003; Karahanna & Straub, 1999).

4.4 Development of Conceptual Theory

TRAM is a combination of TRI and TAM. While TR illustrates the influence that individuals have on the adoption of new technology, TAM forecasts the acceptance of new technology by users. The TRAM model is a version of the TAM model that is extended along with other factors to increase the explanation and prediction of individuals' technological adoption behaviors. This was done so that the TRAM model could exist. The individual's level of expertise and familiarity with technology in general influences both the individual's perception and behavior with regard to the acceptance of new

technology. It is possible to say that TR demonstrates an individual's perspectives on technology in general, whereas TAM connects the perspectives of an individual to the existence of specific technologies. In addition to this, TRAM has been utilized to determine the degree to which users in a variety of industries embrace particular technology (Lin, 2007; McFarland, 2006). Developing an existing research model. The primary model for this investigation is derived from the model, which is then developed by the incorporation of a number of different study variables (Basgoze, 2015; Lin, 2007; Karahanna & Straub, 1999).

The principles of TRI and TAM were first combined into a single model for the investigation. After that, this research incorporates the factors of self-directed learning (SDL) aspect (Long, 1994), and COVID-19 pandemic as a temporarily impacting external variable that accelerates the transformation and the way towards a totally digital working environment (Nafrees, Ponnampalam, Razeeth, Kariapper, & Samsudeen, 2022; McKinsey & Company, 2020).

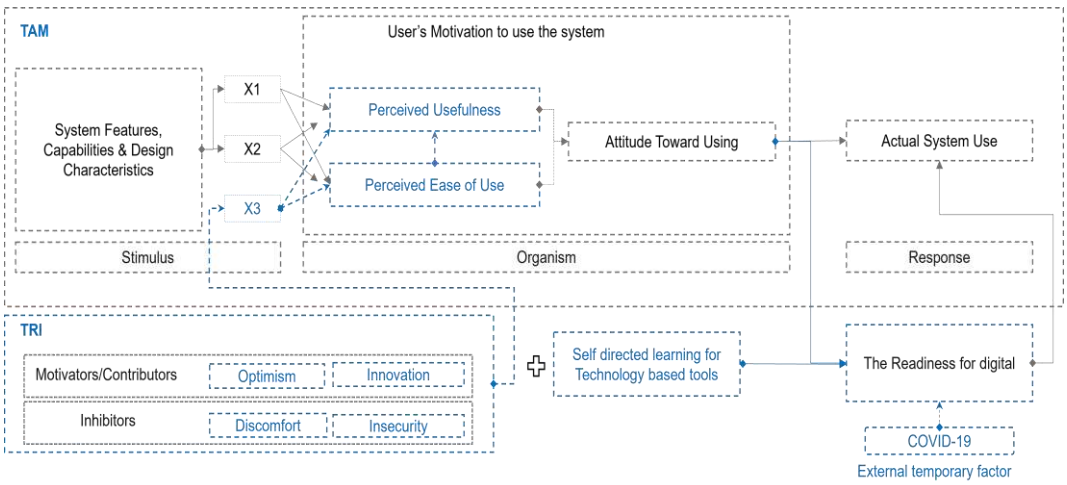


Figure 21 *Proposed Conceptual Model – Source: Author. Based on compiled resources.*

The hypotheses proposed in this research are as follows:

-The optimism (OPT) significantly beneficial affects Perceived Ease of Use (PEOU)

- The optimism significantly beneficial affects Perceived Usefulness (PU)

- Innovativeness (INN) significantly beneficial affects the Perceived Ease of Use (PEOU)

- Innovativeness (INN) significantly beneficial affects Perceived Usefulness (PU)

- Insecurity (INS) significantly negative consequences that affects the Perceived Ease of Use (PEOU)

- Insecurity (INS) significantly negative consequences that affects the Perceived Usefulness (PU)

- Discomfort (DIS) significantly negative consequences that affects the Perceived Ease of Use (PEOU)

- Discomfort (DIS) significantly negative consequences that affects the Perceived Usefulness (PU)

- Perceived Ease of Use (PEOU) significantly beneficial affects Perceived Usefulness (PU)

-SDL affects Digital readiness

-External factors such as the pandemic of Coronavirus (COVID-19) accelerates the transformation.

4.5 Summary

This chapter attempt to explain two very well-known models in the literature: Technology Readiness Index (TRI) and Technology Acceptance Model, proposing a combined research model as an assessment criterion upon which the questionnaire in the next chapter is designed. TRAM model approach is developed by the incorporation of two variables SDL and COVID-19 Pandemic. The Technology Readiness Index (TRI) and the Technology Acceptance Model (TAM) have both been incorporated into this model, in addition to the variables that have been added in this research. This chapter results reveal a new proposed conceptual model to assess readiness and acceptance of architects to technology adoption. Summarized in figure 21.

Chapter 05: Materials and Methods

5.1 Introduction

Following a brief introduction literature review of this discourse, this chapter is devoted to studying relevant case studies in the Egyptian setting to address the major research question of this work.

This chapter focuses on readiness assessment for Egyptian architectural offices architects, by applying the proposed assessment criteria. It is meant to capture a certain point in the architectural profession's "digital transformation journey", investigate, and explore what digital change in architecture looks like and what it implies and means for the profession. With emphasize of the technologies that are being used and how they are affecting the way projects are run as well as the internal workings and dynamics of architectural practices. Also, the examination of which technologies are likely to be significant as the industry continues to evolve rapidly. Additionally, investigation of the advantages that this transition offers to practices, as well as the problems that must be solved. Moreover, it questions readiness and acceptance for adopted technologies and software, through scanning TRI and TAM theories' scales.

5.2 Data Collection and Sampling

As mentioned earlier, this study follows an exploratory and analytical approach. It is based on data from a mixed method that follow both qualitative and quantitative approaches using a questionnaire and interviews (Creswell & Clark, 2011; Greene, Caracelli, & Graham, 1989). The current study's justification for employing a hybrid strategy is to investigate and explore readiness and technology acceptance among the Egyptian architects who are currently working in architectural technical offices. Data collection is sequential starting with the interview in chapter two as a part of building the knowledge regarding the DT initiatives, followed by building the assessment criteria based on literature and case studies, followed by the questionnaire.

The questionnaire is designed to investigate Digital readiness, and Technology acceptance, through their factors adapted from the list of items proposed by Parasuraman and Colby (Parasuraman & Colby, 2015) and from the literature review. The questionnaire language is English and it is structured of two main sections; section one related to personal information, area of knowledge and job description specification, and section two regarding the thesis objective; respondents were asked to identify digital technologies they are you using or planning to invest in through the upcoming years, specify the main challenges, and benefits of adopting digital technologies for architectural practices, what aspects of their work are being changed, or are likely to be changed because of technology.

The questionnaire was launched for 10 days from May 21, 2022, to May 31, 2022. The Cochran formula has been used to calculate the sample size (Cochran, 1963). there was not enough data about the exact number of the Egyptian graduated architects who works in technical offices, so that the following equation was used (Taherdoost, 2017; Israel, 1992):

$$S = \frac{X^2 * y\,(1 - y)}{P^2}$$

The sample size is represented by S, while the desired level of precision is represented by P. (i.e., the margin of error). For y, represents the (estimated) fraction of the population that possesses the desired trait. The X represents the level of confidence required. This final value is calculated from the X-table and aids in indicating what percentage is below the curve at any given time or at any precise point (Alden, 2007; Glen, 2019).

As stated, that the author does not have much information on the number of architects working in architectural technical offices in Egypt, it is assumed that half of their network in the digital social media could be reached via the interface of Facebook, LinkedIn, WhatsApp, and ResearchGate, allowing maximum variability. The total number of architects in the author' network exceeds 3000 persons.

So, y= 0.5 with 95% confidence and at least 5 per cent – plus or minus – precision. This 95% confidence level shows z values of 1.96, per the sample size-table. In this, p=0.08, x= 1.64 and y= 0.5. On this premise, using the sample size calculator of SurveyMonkey to double check, the sample size required would be 143 while in the current research 245 respondents had the interest to participate in this survey in 10 days, which decreases the margin of error to 6%.

5.3 Proposed Assessment Criteria

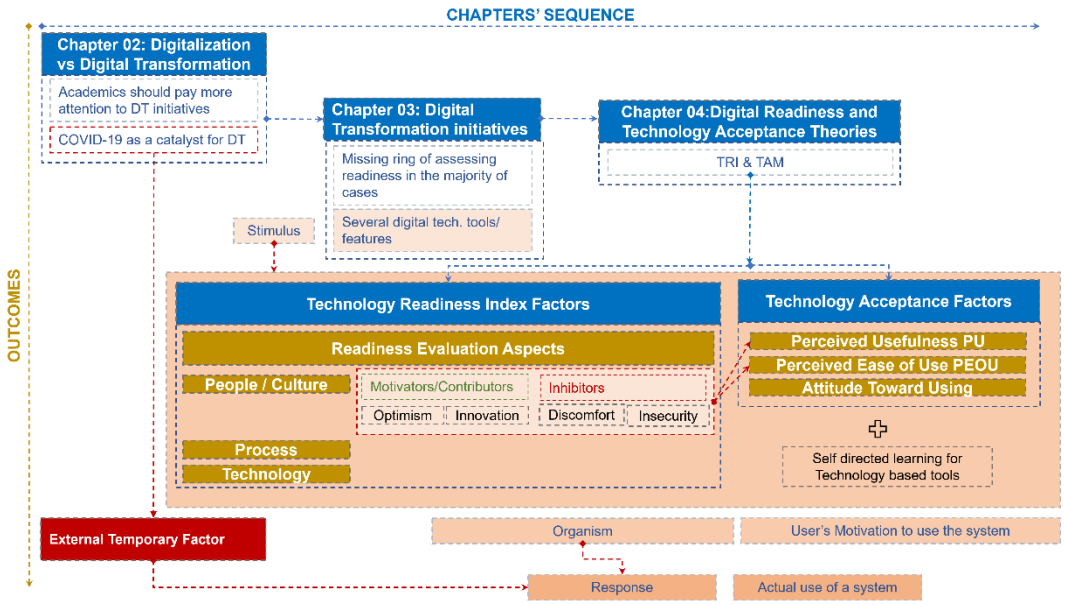


Figure 22 *Criteria for Assessing Digital Readiness – proposed research model. Source: Author*

Based upon the literature in the previous three chapters, a proposed research assessment criteria are formed upon on which the questionnaire was designed to evaluate readiness of architects in architectural technical offices in the Egyptian context.

5.4 Questionnaire Structure

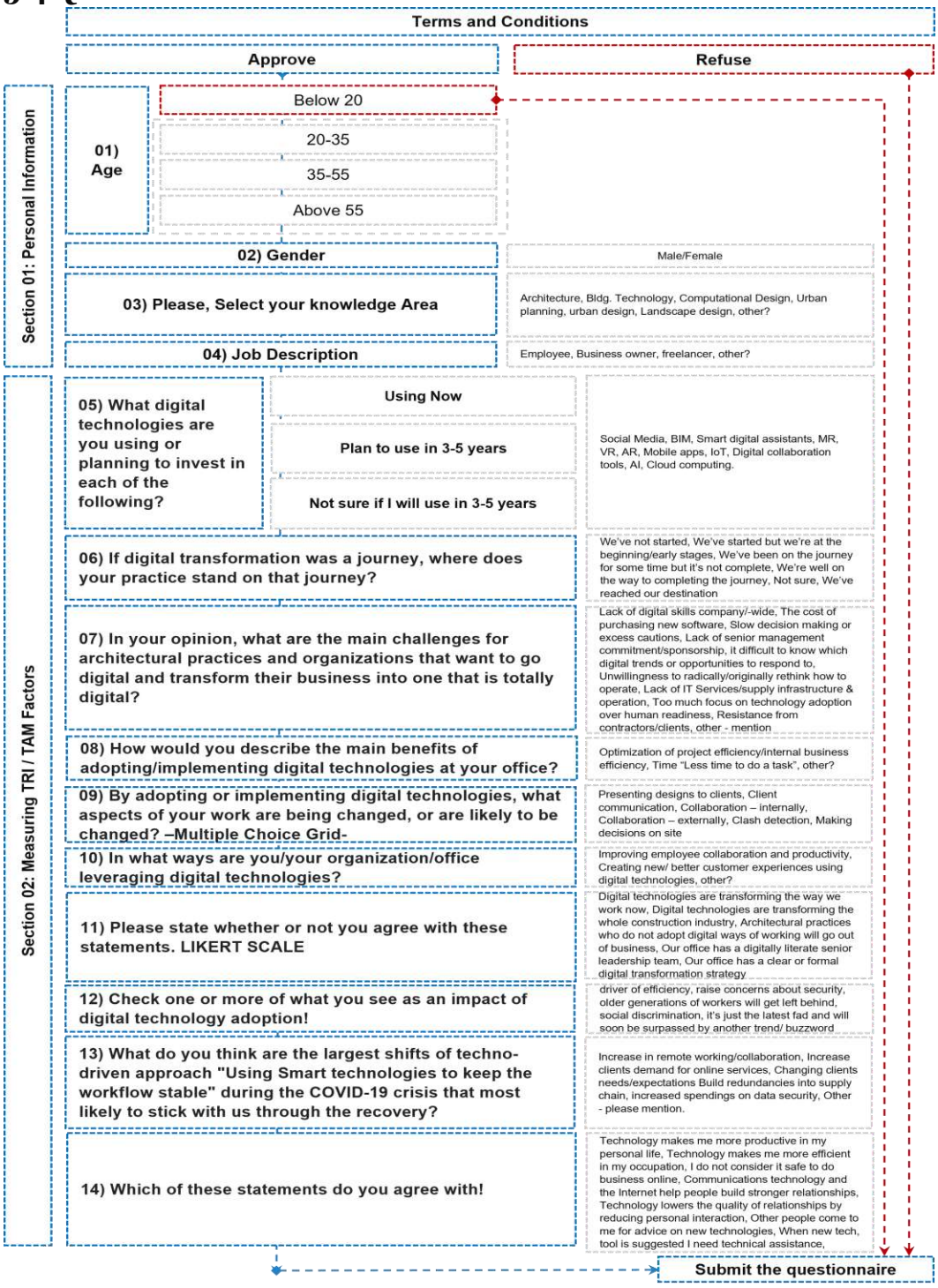


Figure 23 *Questionnaire Structure – Source: Author*

Chapter 06: Questionnaire Results

6.1 Introduction

The purpose of this chapter is to describe and analyze the findings extracted from the sample results of the questionnaire (242 respondents), ignoring two trials of respondents under the age of 20, and one unreliable response and the interviews in chapter 03 (5 interviewees), respectively. By presenting the data collected to be discussed and evaluated, to come to an outlook for technology adoption.

6.2 Results

Our investigation revealed that the phrase "digital transformation" is not common parlance among professionals working in the architecture and built environment. Nevertheless, regardless of whether they are familiar with the language or not, it is clear from the examples provided below that the architectural and design community generally welcomes digital transformation as well as the potential that it presents.

Respondents are from different age groups: 221 respondents are between the ages of 20 and 35, 17 respondents are between the ages of 36 and 55, and 4 respondent is older than 55. Regarding job status 5% of them are business owners/employers, 85% are employees in different architectural offices/organizations, and 10% are freelance architects.

Questionnaire respondents come from a variety of educational and professional backgrounds, 45% have Architecture background only, 40% have Architecture and another discipline backgrounds including building technology, computational design, landscape design, urban design, interior design, urban planning, and Management Engineering, 15% have one of the previously stated disciplines only.

According to the findings of our research, a significant number of architects, 54% of our questionnaire respondents are aware of the significant opportunities presented by digital transformation, they perceive usefulness (PU) of new digital tools and specifically how the process may lead to significant improvements in operational efficacy. Adoption of digital

technology is not a choice but a necessity: 69 percent attribute its importance to the continued existence of their businesses, they see that those architectural practices that do not adapt digital means of working will eventually be forced to close their doors.

However, in the past five years, there has been a shift in the way that practices run; in fact, almost half of those who participated in the survey reported that this shift has been either significant or complete. In particular, the manner in which projects are brought to fruition is undergoing a transformation. Over Ninety percent of respondents told us that digital ways of working have affected this either a great deal or totally. A smaller percentage of respondents, 49%, claimed that they had altered the way in which their organization is managed significantly or entirely. Almost all of them, 95% of respondents, believe that the implementation of digital technologies is currently influencing how they perform their jobs.

The vast majority of individuals who took part in our survey are under the impression that their company is now through some kind of digital transformation journey. 44 percent of those who responded informed us that they were getting close to starting the journey, and 32 percent of those who responded have been on the adventure for some time (Figure 24). 8% of those who responded said that they have not yet started the voyage. Because the digital revolution is currently taking place, those who are not participating run the risk of being left in the dust if they do not join in as soon as possible. Nobody believes that they have arrived at their objective, and only a few people feel that they are nearly finished with the voyage. This makes perfect sense, as digital transformation is more of a continual process of change and renewal than it is a path leading to a predetermined destination (NBS, 2018). Ten percent are unsure of where they are in the trip they are on. This is not due to a lack of knowledge; rather, it is a consequence of the rapidity with which cultural, organizational, and technological norms are shifting.

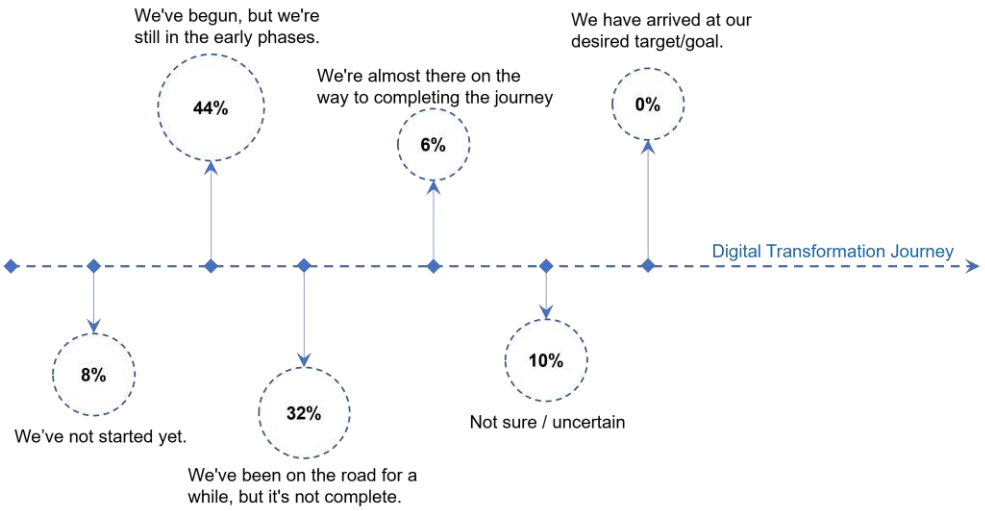


Figure 24 *The vast majority of architectural practices have started their 'digital transformation journey – Source: Author*

Benefits of Digital Transformation

Concerning the question of whether or not we should engage in this transition to digital, over half of our respondents (71%) agree that advancements in digital technology are leading and contributing to increased productivity in project management and are making projects more efficient.

Regarding the DT journey benefits, moving beyond the limitations of traditional screen-based models, mixed, augmented, and virtual reality have the potential to bring a design to life and provide the client the opportunity to truly experience the structure before it is constructed. Putting the client at the center of the design process requires that all members of the construction team, including clients, consultants, and contractors, work together as virtual teams to investigate, evaluate, and come to an agreement on design options. This will save time and money by reducing the need for on-site adjustments and remedial work once construction is complete.

Interviewee A, in the associated linked local case study in chapter two, has explained how he uses virtual reality to digitally revolutionize and transform the way he works in the design process preliminary phases, also it transforms

the way he deals with clients. The client and the architect may now communicate more effectively thanks to the efforts of his practice, which is taking the initiative lead in this area. He claims that he uses virtual reality as a "time machine" to show the client what will be created, bringing early-stage design to life so that better buildings can be produced.

It is not only him; the number of people using these technologies is expected to increase in the near future; currently, 18 percent of architects are utilizing at least one type of mixed, augmented, or virtual reality. A few of those intend to broaden their utilization of immersive technology in the not-too-distant future and make use of additional kinds. Additionally, 47 percent have future plans to utilize mixed, augmented, or virtual reality within the next three to five years.

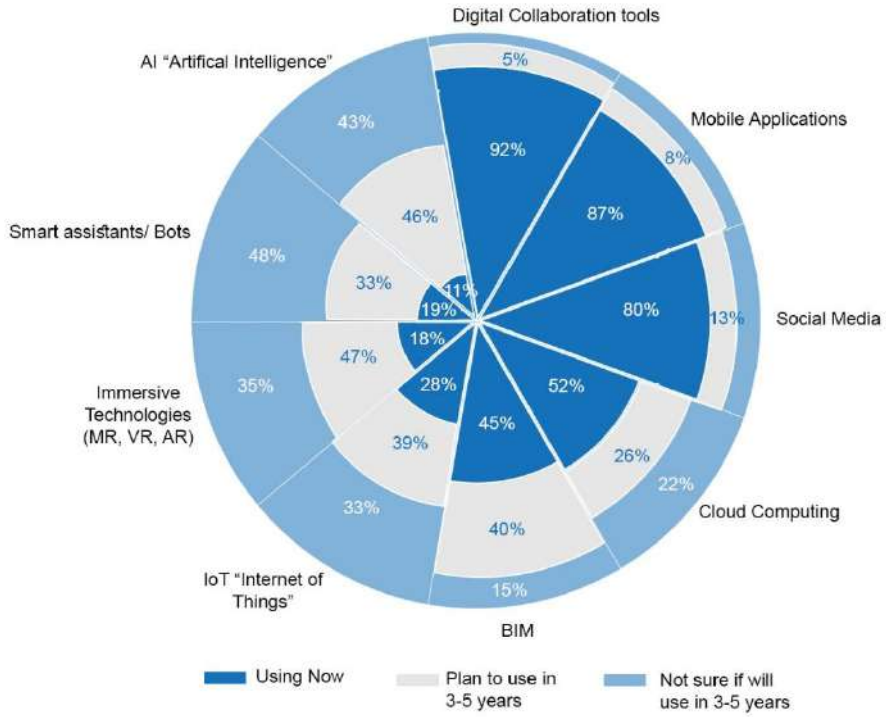


Figure 25 *Digital technologies assist the Digital Transformation journey of architects in the Egyptian context – Source: Author*

The field of architecture is well-known for its originality, innovativeness, and the profession itself is recognized as a pioneering global voice in the evolution of the design process.

Although it is obvious and clear that innovation will take various shapes in the future, we are going to focus on digital collaboration tools that immersed into the architectural work since the COVID-19 epidemic outbreak, such as online meeting platforms, and shared documents, following techno-driven approach "Using Smart technologies to keep the workflow stable" during the COVID-19 crisis, key findings of this questionnaire regarding the largest shifts that most likely to stick with us through the recovery are increasing the remote working as 82% of respondents claim that, 62% declare increase clients demand for online services, 41% proclaim that would result in a change in client needs and expectations, and 52% of questionnaire respondents claim that would increase use of technology tools in several operations.

Moreover, within the realm of architectural practice, Building Information Modeling (BIM) has emerged as the most significant noticeable development in terms of both technology and culture in recent years. 40% of interviewees agree to this. BIM is the first digital construction technology that can be considered truly universal, and it will soon be implemented in every nation on the planet. It is a "game-changer" in the industry. The BIM process is a model for Egypt's ongoing digital transformation, which is being spearheaded by architects. This not only increases productivity but also highlights how digital transformation can rapidly and significantly alter established methods of carrying out work. Results from our questionnaire state that 45% of our respondents are using BIM, 40% have a plan to use it in the upcoming three to five years, so this pattern is not breaking any time soon.

BIM is a collaborative effort; it provides a shared digital information environment in which stakeholders may discuss and reach consensus over the requirements and inputs that are appropriate for each step of the plan of work. It makes it abundantly obvious what should take place when, as well as

who is accountable for it. It is a form of technological advancement. It is dependent on powerful and sophisticated 3D modelling tools that have only become available in the recent past. These technologies have only been available for a few years. In addition to this, it is dependent on developments in the organization and standardization of construction information.

It increases productivity since different members of the project team are able to access, share, and develop a data-rich model that is rendered in three dimensions. The collaborative aspect of Building Information Modeling (BIM) ensures that any conflicts between the inputs of different design disciplines are identified at an early stage, preventing time from being spent on-site. It also gives the structure necessary to shift away from a fragmented and adversarial approach to building, which is something that has been desperately required. Adoption of BIM is leading to decreased costs (in the design, construction, and whole life costs of constructed assets) and increased productivity (by developing efficiencies to minimize the amount of time needed from inception to completion). The delivery of architectural services and outcomes is undergoing a transformation as a result of improved collaboration and information coordination.

BIM also enhances customer results by lowering costs, reducing delays, and providing a higher level of output certainty. In the future, Building Information Modeling (BIM) might make it possible to evaluate design options for projects that are still in the planning stages by collecting real-time performance data from buildings that are already occupied. This technology will make it possible for design to undergo a continual evolution based on data-driven learning and the application of best practices. This transformative competence will require cooperation from across industries, but it will produce major improvements in client results, in addition to advantages for society and the environment.

The adoption of BIM necessitates a cultural shift that goes beyond a simple willingness to embrace new technology. It is an engagement and belief that is held in common by individuals who choose the long-term direction of a practice as well as those who are responsible for the day-to-day operations of the architectural firm/office.

During periods of such fast change, new ways of working frequently flourish and go on to supplant older approaches. We are witnessing the development of various technologies that enable architects to work in a variety of ways, including collaborating, working on-site, or working while moving about.

In addition to building information modelling (BIM), the next wave of digital adoption will see architects leveraging the Internet of Things; a total of 39 percent anticipate adopting this in the next three to five years. 28 percent of respondents are now utilizing at least one of these technologies. The use of mixed, augmented, and virtual reality is also on pace to become significantly more popular over the same period. The adoption of artificial intelligence (AI) and smart bots will take a little bit more time as architects continue to have a better understanding of the prospects associated with developing technology, which is clarified in Figure 25, at the moment, the implementation of these technologies is restricted to a small subset of early adopters working inside a limited number of businesses, or it is being tested out by a few select practices.

These advancements will increasingly be supported by the cloud, which is now used by roughly 52 percent of businesses. This will free practices from the maintenance of their own servers and allow for reliable access to project data whenever, wherever, and however one chooses to do so. This is beneficial for a job that is becoming more globalized and involves working between offices and sites located all over the world.

The vast majority of practices are currently utilizing digital collaboration tools (92%), and mobile/apps (87%), social media (81%) Summarized in Figure 25.

Over half of respondents who claim to use digital collaboration tools (223 respondent out of 242 (92%)), say digital technology is affecting how they do their work, and they agree that it is a driver of efficiency as 70% of them (157 respondent out of 223 using digital collaboration tools) have claimed that technology makes them more efficient in their job, which clarifies that they perceive usefulness (PU) of such tools and ease of use (PEOU) as well.

As a further matter, these technological advancements such as mixed reality, AI, BIM, cloud computing, mobile/apps, digital collaboration tools and social media will cause significant changes to the architectural practice as 65% of our respondents believe and agree that these technologies are motivators and contribute to their occupation efficiency.

Moreover, it is more likely that younger professionals would recognize the advantages of digital transformation, almost half of the respondents see that DT is a driver of efficiency, a force for good change. 48% of those respondents in the age group of 20 – 35 (105 respondents out of 221 aging 20-35) are using BIM technology now, while 29% of those in the age group 36 – 55 (5 out of 17 respondents whose age group 36-55) are using BIM these days, and 0% of those above 55 years old are using BIM, which is also highlighted in this questionnaire results that reveal that younger generations are likely to use, see and appreciate the impact of technology on the architecture society, and have less chances to recognize negative outcomes, which is a shift in culture and a force for good in the way forward of transformation. Encapsulated in figure 26.

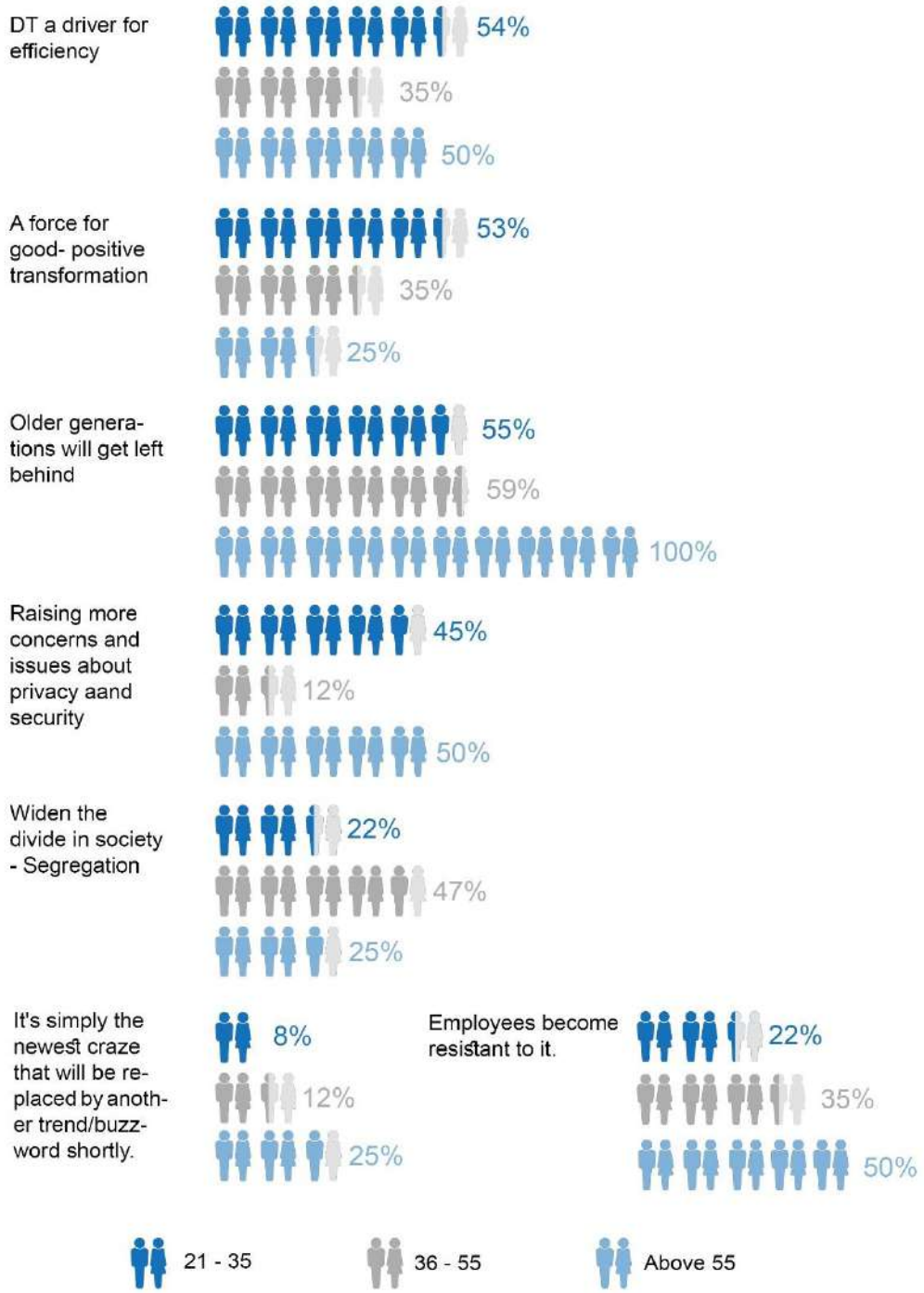


Figure 26 *Impact of Digital Transformation on society by age – Source: Author*

Challenges Associated with Digital Transformation

To become digital-first and to keep that status requires enormous effort and commitment, and transformation is not a simple easy process, it faces numerous challenges. When running an architectural practice, profit margins are frequently thin, with high cost to purchase software at the preliminary stages of transformation, cost is one of the biggest barriers for architects to adopting digital technologies and procedures that lead to better cooperation, as we've already noted, 57% of our respondents agreed on that. In addition to the financial outlay expenses required to acquire new software, an expenditure of both time and money is necessary to train employees on its use.

The volume of work is typically high, and the need to consistently bring in new clients is constant. Maintaining financial stability in the present while still making investments for the long term is a delicate balancing act. Facing at the same time a major challenge of lacking IT services and infrastructure as 45% of questionnaire respondents declare such issue.

Moreover, it is easy to make the mistake of thinking that raising an organization's productivity is simply a matter of the people working harder and ‘smarter' within that organization. This misconception is a common one. This is an overly simplified explanation. When it comes to the production of goods or the provision of services, a person's level of productivity is determined not only by the equipment at their disposal but also by the talents of the individual who is performing the activity.

"Less time" depends on your ability to use tools, in addition to the talents that are unique to your trade." -A Quote by a Questionnaire respondent who is a business owner/employer.

A person's amount of education and training determines their skill set. Qualifications in architecture are earned after years of study in addition to experience gained via practice. But the extent to which an organization or a

group of experts share their knowledge and the methods that have proven to be most effective is another factor that affects skill levels.

At the heart of digital transformation is the process of providing individuals working within a practice performance with the knowledge and abilities necessary to take ownership of existing processes and further innovate upon them. According to the results of our poll, investing in skills is necessary for digital transformation.

Respondents ranked a shortage of digital skills as the first major obstacle they face; in all, 59 percent of respondents mentioned this issue. Also 38% claimed that when a new technology gadget, tool or software is suggested, they need technical assistance. 56% of the respondents see a clear impact of DT is that older generations will get left behind either because they do not find it easy to deal with new tools and software interfaces or they lack the skills, have no motivation or eagerness to try or even because it is a matter of discomfort and feeling of insecurity in dealing with technology.

Figure 27 *Challenges/difficulties that represent Cultural obstacles to digital transformation– Source: Author*

In addition to the obvious tangible and intangible obstacles, there are also specific impediments inhibitors to overcome when it comes to making use of technological advancements and getting ready to acknowledge, accept and adapt to them, as 59% of the questionnaire respondents declare that technology degrades the quality of human connections, because it encourages less face-to-face engagement which causes an insecurity regarding their perception to technology. 34% of the respondents claimed that they don't consider it safe to provide personal information over the internet, and 44% proclaim that when they approach a company, they much rather have a conversation with a real person than deal with their automated service system. These inhibitors results indicate the insecurity factor being highlighted.

Other inhibitors whose presence is demonstrated and verified by the presence of the discomfort factor in the questionnaire findings, 14% proclaim that technology seems to fail at the worst possible time, 17% of respondents do not consider it safe to do business online, and 38% of respondents declare that when a new technology gadget, tool or software is suggested they need technical assistance, which also indicates the difficulty in self-learning of tools as 4% of respondents quote that the tool type and its interface indicates the Perceived ease of use (PEOU) which after that reflects on the ease of self-learning and solo using of the tool without the need of technical assistance, and by default decrease the time needed to finish any task.

Another respondent quote that,

"When we have a complete understanding and fully aware of the powers that digital technology may provide, this is when we could consider decreasing the time needed to do a task, as it is difficult in architecture to undertake "art and design" creative work through technical means while maintaining and ensuring the same level of humanity, we will have reached a turning point."

which is a challenge in the core of the meaning of architecture that we should not overlook.

One of the main findings of this study, the challenges associated with collaboration and client satisfaction, so in the next section of this chapter we will explain why collaboration is needed and what are the challenges affecting the way forward.

Collaboration and Client Satisfaction

It is commonly known that the construction industry struggles with working together effectively. It has been defined, explained, and articulated how essential increased collaboration will be over the duration of the construction timetable. The act of working together has many advantages, including the following: There is a standardization of the information, because information is shared, it is now in a position to be used, both traditional and forward-thinking methods of accomplishing goals are discussed and passed on, the procedure is open and accessible to all parties, which enables appropriate distribution of risk and responsibility, construction issues are approached with a variety of perspectives in order to generate viable solutions, there is a larger possibility that the entire life cycle of the construction project will be taken into consideration, and better client outcomes.

The move to digital has provided us with fresh approaches to solving these age-old problems regarding collaboration. The change to a digital environment has made it possible to collaborate in new ways, allowing us to jointly generate, aggregate, evaluate, and share information regarding design and construction. As mentioned earlier, the architects are perceiving the usefulness of digital collaboration tools 92 percent of them have agreed that using digital collaboration tools, social media apps and mobile devices in remote working/Collaboration as a quick response to COVID-19 is likely to stick with us through the recovery.

We were told by 41% of respondents (100 out of 242) that digital technologies had altered the way in which they cooperate with external parties (Figure 28). This requires a more efficient collaboration among the various design disciplines as well as with the contractors. As a result of federated models bringing together architectural, structural, and M&E designs, clash detection has improved (41 percent of people feel that digital technology is responsible for this improvement, Interviewee B claims that new software and technology tools have helped them in the office to solve technical installation problems through auto generation of several iterations.

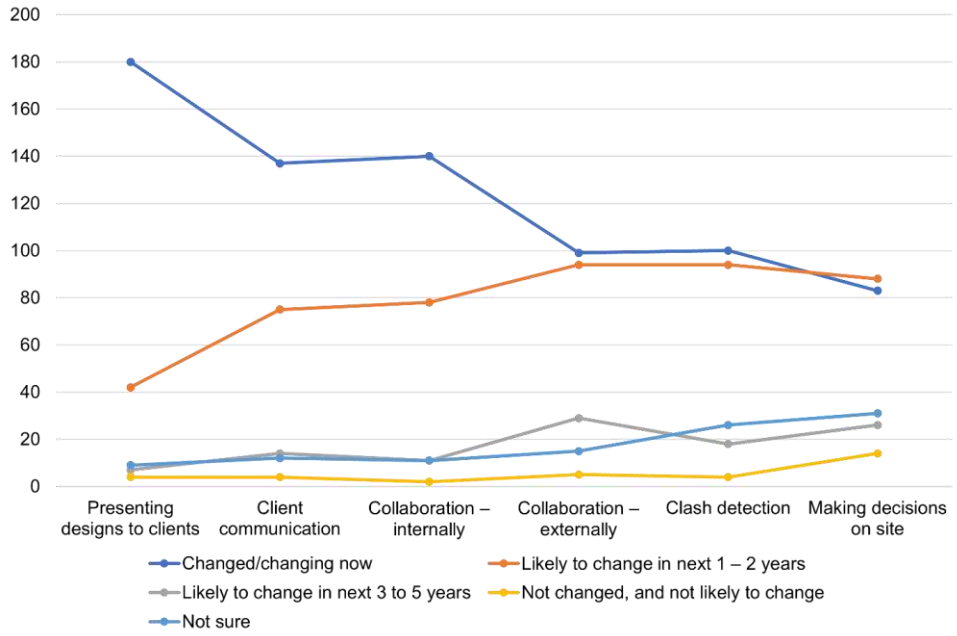


Figure 28 *Teamwork and collaboration aspects that are enhanced by Digital Transformation – Source: Author*

Another aspect to be considered is that the shift toward collaboration needs to take place within organizations for it to be successful; hence, we discover that digital technologies are assisting 58 percent of practices in their efforts to interact internally. A majority of architectural practices, or 74%, are making use of the opportunities that digital technology and ways of working bring to the table in order to boost the collaboration and productivity of their

staff members. Another important development is the shift in the ways in which architects collaborate with their customers. Almost two quarters of architects, or 74%, have altered the way in which they offer designs to customers, and only slightly more than half, or 56%, have altered the way in which they engage with customers. Clients are able to see their building before it is constructed thanks to more realistic renderings of ideas achieved through computer-generated imagery as well as through mixed, augmented, and virtual reality. Clients are better able to ensure that the design meets their requirements and expectations as a result of these adjustments.

One of the challenges that the sector as a whole face is the requirement to broaden collaboration to include all stakeholders. BIM is being used and driven by designers and primary contractors, but it is not always trickling or passing through to sub-contractors and those working onsite: only 34 percent reported that the way choices are being made on site are changing (All encapsulated in Figure 28)

Moreover, a change in culture is also required for true cooperation; specifically, a culture in which responsibility, risk, and profit are proportionately shared and collectively owned by the group. 81 respondents which is equivalent to 34%, as well as Interviewee A&B, in the interlinked case studies in chapter 2, agree that a core challenge is the unwillingness to radically originally think how to operate after adopting new technologies.

This also indicate the existence of cultural barriers to achieve digital transformation. As previously stated, that a major reason is the cost, A sole concentration on costs may lead to erroneous conclusions. The dangers associated with choosing not to invest might frequently be more significant. The implementation of innovative technology in an organizational culture that encourages change has the ability to boost both commissions and internal efficiency, and as a result, revenue, and profit.

If we take a closer look at Figure 27, we notice that there is a problem with the culture, that decision-making is delayed, that there is a lack of radical thinking, and that there is either an unwillingness or an inability to change the culture. This highlights the need of having leadership that is literate in digital technology and is ready and prepared to establish a culture of digital transformation.

The results of our study reveal, on the contrary, that there are certain leaders who still need to come around to the idea of digital transformation. 49% of practices consider their leadership to be technologically literate, which is less than half of all practices (Figure 29). They also claim that their company has a formal or well-defined digital strategy. There is work that has to be done by the leaders of the profession.

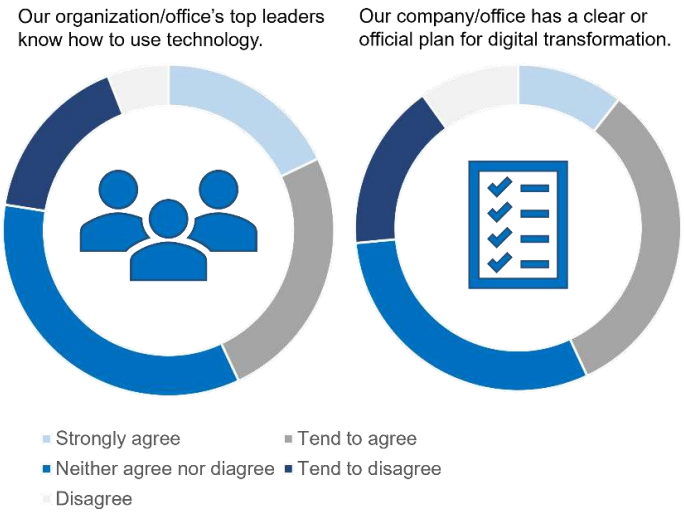


Figure 29 *Indications of the presence of a culture that supports digital transformation – Source: Author*

The archives of technology are replete with examples of problems solved without the need for any underlying issues, cost overruns, and the propensity of vendors to overpromise and underdeliver. Because of these variables, it is essential to form professional teams that are digitally literate. These teams

should consist of individuals who are qualified and authorized to evaluate new technology and direct the practice-specific deployment of it.

On a positive note, the interviews of the interlinked case study results reveal that there is a proof of behaviors that foster a culture that encourages and promotes digital transformation, it is obvious that employees as well as business owners are introducing new technologies/ways of working into their offices, perhaps indicating a culture that supports innovation from the bottom up.

A culture of transformation would be one in which professionals are given the authority to investigate novel approaches to completing tasks, the freedom to take the initiative in bringing about change, and the education and resources necessary to carry out these responsibilities. This is something to keep in mind for the long run: a business model that is flexible enough to accommodate and capitalize on the technology advances that are currently being made as well as those that will be made in the future. Certainly, instructions from upper management are not enough to single-handedly produce a culture. Everyone within the practice is responsible for generating the momentum to adapt to promptly and effectively, and drive, change. The leadership must be able to use technology and engaged in order to define the course for the practice.

The findings from the interviewees' responses are consistent with the opinions of certain academics who stress the significance of acquiring knowledge and expertise in computing methods (Abusaada, Vellguth, & Elshater, 2019; Toimah & Afifi, 2019; Bahrainy & Manshadi, 2017). In their conclusion, some researchers argue that having current abilities that involve the use of digital technology can benefit from the techniques that achieve more realistic results about the issues that confront the built environment experts in the digital transformation path (Moon, Baker, Roy, & Bozzorg, 2014).

Key findings from the interviewees' responses are that the majority of the interviewees clarified that the Egyptian architecture context has variety in digital tools adopted in offices and laboratories attached to them.

They all agreed on adopting the experimental approach of transformation, which enables their offices to try out numerous new ideas inexpensively and focus on empirical results. Regarding PU, PEOU, Readiness motivators, they have highlighted the optimism, innovation, passion, and eagerness of their employees and trainees to learn, even though there is no pre-readiness assessment in the preliminary phases before purchasing and adopting tools, which sometimes result in wrong decisions in choosing tools or in in choosing what digital trend to tackle.

The vast majority has declared the importance of training sessions, even though interviewee C is the only initiative that has a trainings agenda.

Wrapping up challenges and limitations, the interviewees have agreed upon the financial resources, and issues in regard to lack of time to train employees of how to utilize new technology gadgets as the top challenges.

6.3 Reflection on Assessment Criteria with the Results

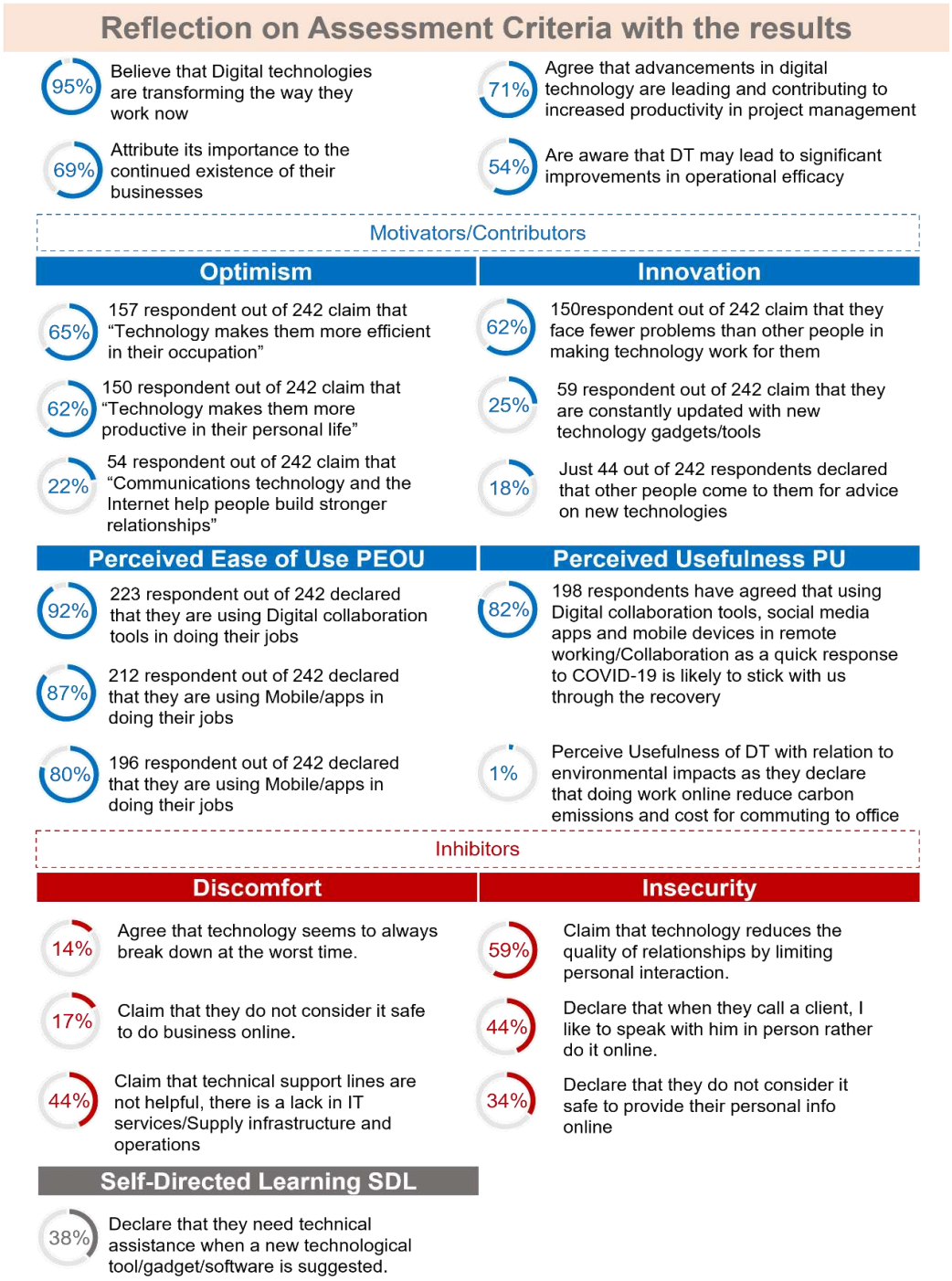


Figure 30 *Reflection on the measured factors of assessment criteria with the questionnaire results – Source: Author*

Chapter 7: Discussion and Conclusion

7.1 Cumulative Summary

Creating a digitally ready architecture society demands a holistic strategy spanning multiple components. Digital transformation involves reimagining how you bring together people, data, and processes to provide value for your consumers and maintain a competitive advantage in a digital environment.

This thesis concludes by arguing that the gap between the Digital transformation aspects adoption and architects' readiness can be bridged. The first aim of this study is a literature review covering scientific research, articles, and conference proceedings for both terminologies "Digitalization" and "Digital Transformation". The second aim of his study is to provide a reflection on DT journey, types, approaches, tracks, and suggests a further deep dive into the process of digital transformation, as digital transformation is an enthusiastically discussed topic these days because it affects the business economy and, because of the pandemic that highlighted the need for the shift and accelerated the process.

Approaching several global and local DT initiatives, this research has demonstrated that training skills, supporting fundamental human requirements, building a business-friendly and start-up environment, and business investments will benefit offices in their digital future.

This study neatly builds on previous works evaluating digital maturity and readiness with its dimensions, through constructing a conceptual model that combine both TRI and TAM theories with the incorporation of the factors of self-directed learning (SDL) aspect and COVID-19 pandemic as an external temporary aspect. The results demonstrate that though we cannot predict the future, we can help people participate if we empower them to become global issue solvers and provide them with the necessary skills.

Last but not least, this groundwork has made it possible to identify valuable aspects to be approached, theories to be followed, reaching at the end the fundamental phases necessary to have a generic process for digital

transformation and presented as a roadmap outlook for digital technologies adoption. In which we conclude that, architecture and design professions need to begin planning for the future as soon as possible. They must consider and discuss the potential trends, opportunities, and difficulties that the digital revolution may bring in order to be ready to adapt when the time comes.

We are optimistic that our research will serve as a springboard for new ways of thinking about it and planning for the future. This research might be a teaser for researchers to tackle a topic that is not approached that much. so, more reviews and research should be done not only to update the data in this initial research, but also to provide more ideas on currently under studied issues.

7.2 Rethinking of Digital Technologies Adoption

According to the findings of this study, members of the design community, including architects, are making effective use of the digital tools that are accessible to them. They are in the process of modifying how they work right now, and this trend will likely continue in the not-too-distant future. The majority of practices have already begun their journey toward digital transformation (even if they don't call it that), and the majority of them are aware of the benefits of doing so.

It should not come as a surprise that BIM is having a greater impact on the workflow of practices than any other technology or methodology. BIM is not just a single technology or method; rather, it is a methodology that is revolutionizing an entire industry and paving the road for the implementation of additional innovative digital advancements. Mixed, augmented, and virtual reality, as well as the Internet of Things, are some examples of the next wave of digital technology, which is now being accepted by innovators and early adopters. In addition to these technology, architects and designers are utilizing other tools that have become widespread in today's culture and have been shown to promote communication and cooperation. These tools include social media, mobile devices and applications, and cloud computing.

There are obstacles to digital transformation, the most notable of which being: foremost the expense involved in making investments in both hardware and software as well as the continued education of employees. This difficulty is quite real, but practices of all sizes have spent time progressively enhancing their "back office" set-up. These improvements include adopting modelling software, educating staff, and assigning different members of the team responsibility for different aspects of digital transition. This prognosis for the long term, which is motivated by practice leaders, but carried out by personnel who have been given more responsibility, reflects a culture that welcomes change. Some practices have not yet developed their culture in this manner because they either lack the leadership and decision-making to take the essential steps or they are resistive to the change in and of itself.

Reimagining the ways in which you bring together people, data, and processes to produce added value for your customers and keep a competitive advantage in a world that is increasingly dominated by digital technology is at the heart of digital transformation. The ultimate goal is for digital transformation to help create better buildings and places and improve client outcomes.

We require a mindset that is open to change. As previously stated, that digital transformation is more of a continual process of change and renewal than it is a path leading to a predetermined destination. So, a company's day-to-day operations can undergo a transformation and become more streamlined through the implementation of digital transformation, which is the all-encompassing integration of digital technologies. Additionally, it establishes an atmosphere and culture that demand proactive participation from all employees within the firm.

Architectural firms and offices that have fostered a culture of innovation will be prepared to adjust to the industry's forthcoming shifts and will be best positioned to profit from them. They are going to complete one another in ways that we might not be able to foresee at this point (NBS, 2018).

Rethinking of how to build a roadmap for Digital transformation concept adoption outlook, requires the understanding that typically, the first step on a roadmap for digital transformation is an analysis of the current state of the system and a description of its ideal future state. You will, in all likelihood, be aimlessly roaming around your digital transformation endeavor if you do not have a map, which poses a significant threat to the future of your system. How can you tell if you're heading in the correct direction if you don't know where you're headed in the first place?

A roadmap for digital transformation typically includes a variety of technological projects, process alterations, and organizational shifts, all of which are interdependent on one another for the transformation to be successful (Zaoui & Souissi, 2020).

The roadmap critical essential elements are a vision statement of where your company/system is trying to go, a strategy for arriving at your destination, key activities of the transformation and the milestones you'll encounter, and a pre-readiness assessment as well (Zaoui & Souissi, 2020).

Moreover, the outlook elements could be broken down into four major tracks that should be tackled within a clear vision and strategy: people, process, technology, and content (Newman, 2018).

1. **People Track**

   The people track entails the creation of a people-centered culture within your organization. Additionally, it discusses the role that business partners play in the creation of this vision, as well as personalizing how buyers interact with a company's or system brand and involving all members of a company or organization through cross-functional collaboration (Newman, 2018).

   Additionally, **include and empower employees**, as employees frequently have abilities and ideas that can propel a company ahead.

Giving them responsibility encourages them to stay and put their knowledge and abilities to use (NBS, 2018).

2. Process Track

In order to improve organizational efficiency and accomplish scalability for its new business model, the process track calls for a study of the lifecycle, which includes the creation of a map of the journey. The purpose of the process track is to acquire an in-depth comprehension of how each and every individual interacts with your system over the entirety of the experience lifetime (Newman, 2018).

In other words, **bring in the proper skilled people**, Collaboration with organizations that have experience with digital technology or hiring personnel with specialized abilities may boost efficiency (NBS, 2018).

3. Technology Track

Selecting the technology path on a digital transformation roadmap directs attention to the process of constructing an information infrastructure that is integrated. This path lays the groundwork for integrating data across several data silos and makes it possible for all information management platforms to communicate with one another. This makes it possible for data analytics to propel growth. Combining the use of software and hardware should be an integral part of the technological strategy employed by a firm or organization (Newman, 2018).

Look for new ways to innovate, investing in hardware and software is necessary. Some clients may encourage or require the use of technology in their project, which may contribute to the funding of such an expenditure (NBS, 2018).

4. Content Track

The fourth is the content track, which focuses on the management of the company's or system's internal information as well as the exterior messaging that faces people. Accurate, tailored, and contextually relevant content is essential to its effectiveness and must be easily locatable by the target audience (Newman, 2018).

Take a business-oriented attitude, Practices that prepare for change, define goals and strategies, and track progress have been demonstrated to be effective in implementing new technology (NBS, 2018).

The practices of architecture and design need to start preparing for the future as soon as possible. They need to think about and have conversations about the possible trends, opportunities, and problems that the digital revolution may bring in order to be ready to adapt when the time comes for it. We have high hopes that this research will serve as a springboard for new ways of thinking about it and preparing for the future.

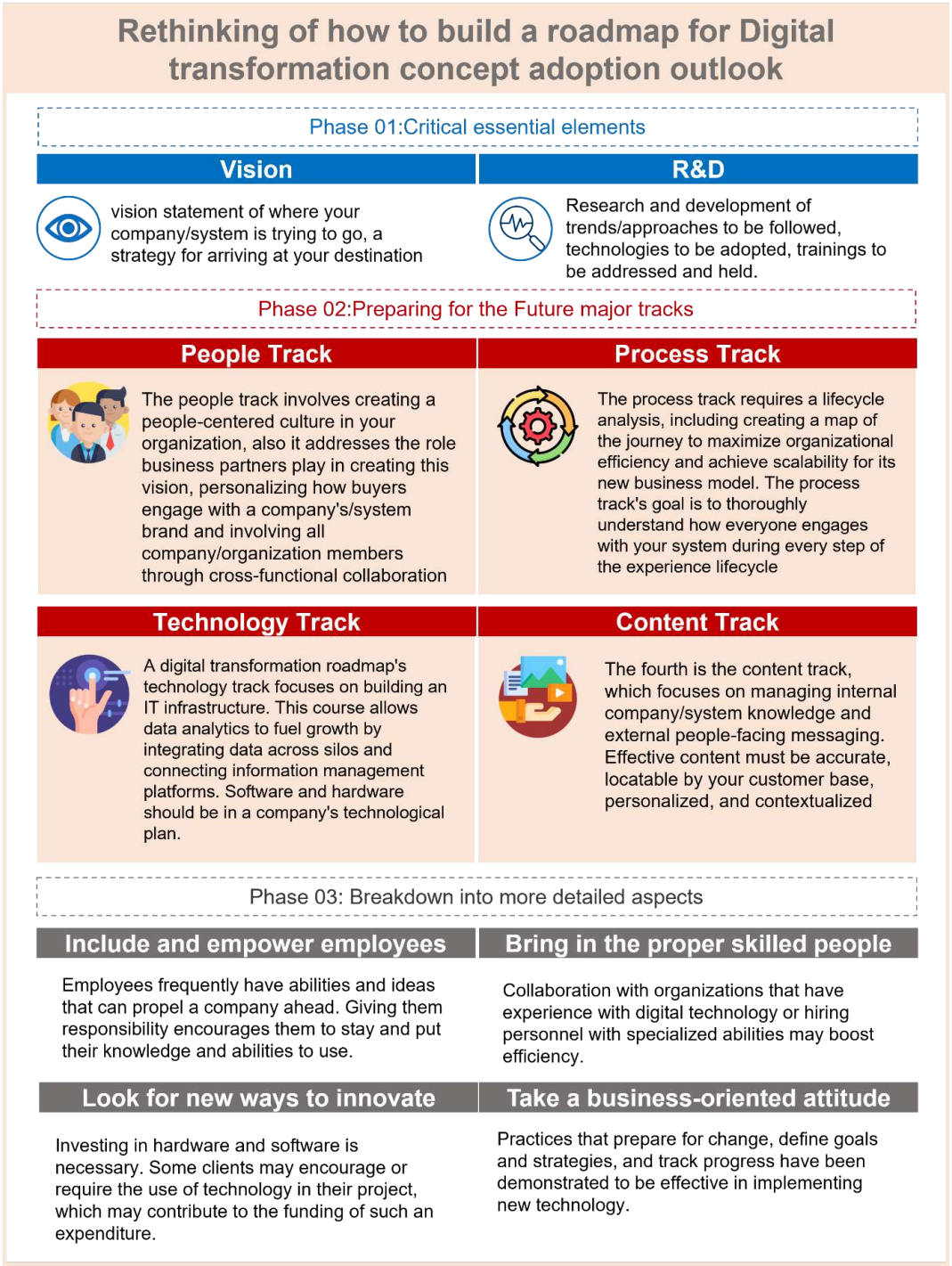


Figure 31 *Rethinking of how to build a roadmap for DT concept adoption Outlook – Source: Author*

7.3 Limitations

The scope of this research focused on human perception to technology, acceptance, and readiness. The physical settings that might be meaningful for employees' readiness, such as networks, and wide range of tangible aspects that were difficult to be covered in this investigation. So, it is recommended for further research.

The limitation of using mixed data gathering and analysis approaches take time to evaluate and analyze all data collected in distinct periods (Bernard, 2011; Creswell, 2003).

The literature review also highlighted some other viewpoints, most of which have gotten very little attention up to this point, considered as gaps in literature that were not under coverage in this thesis due to the limitation of time, highlighted in chapter 02 summary that the VOS-Viewer software bibliometric mapping results have showed how quickly the COVID-19 epidemic has become a topic of interest in the literature over the past five years. However, no attention grabbed to its role in speeding up DT and showing the problem of social inequality. So, more debates and future investigating of the link between the pandemic, DT, and social discrimination could be helpful.

Additionally, a fully thorough approach to producing a systematic literature review also necessitates the use of more than one digital scientific database; as a result, by investigating additional scientific database in addition to WOS scientific data base, the results that are obtained can be different; however, because the emphasis in this research is on openness, transparency and the simple easy reproduction of outcomes, we may be willing to accept this option.

Moreover, in this research, two theories are followed regarding readiness and technology acceptance, to produce the conceptual assessment criteria which are the TRI & TAM. There are other theories that might lead to another

conceptual model proposals such as technology reasoned action TRA developed by (Ajzen & Fishbein, 1975) , Extended technology acceptance theory TAM2 developed by (Venkatesh & Davis, 2000), and the Unified Theory of Acceptance and Use of Technology UTAUT developed by (Venkatesh, Morris, Davis, & Davis, 2003). Digging deeper into understanding these theories also could be useful for further investigation and research.

Another aspect to be mentioned, the limitation of not having any sort of data that determines an exact number of Egyptian architects who work in architectural offices.

7.4 Future Outlook

For further research, a wider sample of interviews for this kind of research is preferable for deeper understanding of physical attributes and indicators that affect readiness.

Moreover, it would be useful to dig deeper in understanding the attitude toward Technology-Based Self-Directed Learning (SDL) as a factor that affect technology acceptance as well as the physical settings and the different technology acceptance theories as previously stated.

Bibliography

Abusaada, H., Vellguth, C., & Elshater, A. (2019). *Handbook of Research on Digital Research Methods and Architectural Tools in Urban Planning and Design*. Hershey, PA: IGI-Global.

Adiyarta, K., Napitupulu, D., Nurdianto, H., Rahim, R., & Ahmar, A. (2018). User acceptance of E-Government Services Based on TRAM model. *The 7th AIC-ICMR on Sciences and Engineering-IOP Conf. Series: Materials Science and Engineering 352 012057*. IOP Publishing-doi:10.1088/1757-899X/352/1/012057.

Ajzen, I., & Fishbein, M. (1975). *Understanding attitudes and predicting social behavior*. Upper Saddle River, NJ: Prentice Hall.

Alden, J. (2007). Surveying attitudes: questionnaires versus opinioinnaires. *Surveying Attitudes: Questionnaires versus Opinionnaires Performance Improvement, Vol. 46 No. 6*, 42-48.

Bahrainy, H., & Manshadi, E. (2017). "The most important skills an urban planner needs in a developing country", The Case of Iran. *Planning Practice & Research, Vol. 32*, 466-477.

Basgoze, P. (2015). Integration of Technology Readiness (TR) into the Technology Acceptance Model (TAM) for m-shopping. *Int. J. of Scientific Research and Innovative Tech. 2*, 26-35.

Bernard, H. (2011). *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. Oxford: AltaMira Press.

Bharatula, S., & Murthy, B. (2020). *Digital Readiness Index—Empowering the nation*. Singapore: Springer.

Bissada, D. (2021, September 05). *Egypt - Country Commercial Guide - Information and Communications Technology; and Digital Economy*. Retrieved from International Trade Administration: https://www.trade.gov/country-commercial-guides/egypt-information-and-communications-technology-and-digital-economy

Chuttur, M. (2009). Overview of the Technology Acceptance Model: Origins, Developments and Future Directions. *Association for Information Systems - AIS Electronic Library (AISeL)*, 9-37.

Clerck, J. (2017). *Digitalization, Digital Transformation: The Differences*. Retrieved from i-scoop: https://www.i-scoop.eu/digital-transformation/

Cochran, W. (1963). *Sampling Technique*. New York, NY: John Wiley and Sons Inc.

Collin, J., Hiekkanen, K., Korhonen, J., Halén, M., T., I., & Helenius, M. (2015). *It Leadership in Transition-the Impact of Digitalization on Finnish Organizations*.

Creswell, J. (2003). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. London: Sage.

Creswell, J., & Clark, V. (2011). *Designing and Conducting Mixed Methods Research*. Sage, London.

Davenport, T., & Redman, T. (2020, May 21). *Technology And Analytics*. Retrieved from Harvard Buisness Review: https://hbr.org/2020/05/digital-transformation-comes-down-to-talent-in-4-key-areas

Davis, F. (1985). *A technology acceptance model for empirically testing new-end users information systems: Thory and results. Unpublished doctoral dissertation*. Cambridge, MA: MIT Sloan School of Management.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of information technology. *MIS Quarterly, 13(3)*, 319-40.

Eisenhardt, K. (1989). "Building theories from case study research". *Academy of management review*, Vol 14 No 4; pp 532-550.

Eling, M., & Lehmann, M. (2018). The impact of digitalization on the insurance value chain and the insurability of risks. *Geneva Pap. R. I.-ISS 43(3)*, 359–396.

Furjan, M., Pupek, K., & Pihir, I. (2020). Understanding Digital Transformation Initiatives: Case Studies Analysis. *Business Systems Research*, vol. 11 No. 1 - pp.125-141.

Ghoneim, A. (2021, May). *The Egyptian Cabinet - Information and Decision Support Center IDSC*. Retrieved from Egypt Digitalization - In Alignment with Egypt vision 2030 for SDGS: https://idsc.gov.eg/Upload/DocumentLibrary/Attachment_A/4798/3%20-%20EGYPT%20DIGITALIZATION.pdf

Glen, S. (2019). *Z-table (right of curve or left)*. Retrieved from data science central: www.statisticshowto.datasciencecentral.com/tables/z-table/ (Last reviewed April,2022)

Gobble, M. (2018). Digitalization, digitization, and innovation. *Res. Technol. Manag. 61(4)*, 56-59.

Greene, J., Caracelli, V., & Graham, W. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis, Vol. 11 No. 3*, 255-274.

Guest, G., MacQueen, K., & Namey, E. (2012). *Applied Thematic Analysis.* CA: SAGE Publications, Thousand Oaks.

Gupta, M. (2020, March). *What is Digitization, Digitalization, and Digital Transformation?* Retrieved from ARC Advisory Group: https://www.arcweb.com/

Hansen, H., & Salskov-Iversen, D. (2005). Remodeling the transformational political realm: partnerships, best-practice schemes, and the digitalization of governance. *Alternatives 30(2)*, 141–164.

Henriette, E., Feki, M., Boughzala, I. . (2015). *The shape of digital transformation: a systematic literature review*. Information Systems in a Changing Economy and Society - p 431 .

Hrustek, L., Kutnjak, A., & Tomičić Furjan, M. (2019). "Implementation of digital transformation in curricula – insights based on analyzing leading universities". *Proceedings of the 11th International Conference on Education and New Learning Technologies EDULEARN* (pp. pp. 5413-5420.). Palma, Spain: IATED,.

Israel, G. (1992). *Determining Sample Size.* FL.: University of Florida.

Karahanna, E., & Straub, D. (1999). The psychological origins of perceived usefulness and ease of use. *Information and management*, 237-50.

Li, F. (2018). "Why western digital firms have failed in China". *Harvard Business Review*, available at: https://hbr.org/2018/08/why-western-digital-firms-have-failed-in-china. Retrieved from https://hbr.org/2018/08/why-western-digital-firms-have-failed-in-china.

Li, F. (2020). Leading digital transformation: three emerging approaches for managing the transition. *International Journal of Operations & Production Management, Vol 40, Issue 6*, 809-817.

Li, J., Merenda, M., & Venkatachalam, A. (2009). Business process digitalization and new product development: an empirical study of small and medium-sized manufacturers. *IJEBR 5(1)*, 49-64.

Lin, C. S. (2007). Integrating technology readiness into technology acceptance: The TRAM model. *Psychology & Marketing,* , 641-657.

Long, H. B. (1994). Resources related to overcoming resistance to self-direction in learning. *New Directions for Adult and Continuing Education*, 64, 13–21.

Machekhina, O. (2017). Digital of education as a trend of its modernization and reforming. *Revista Espacios 38(40)*, 26-31.

Manzoor, B., Othman, I., & Pomares, J. (2021). Digital Technologies in the Architecture, Engineering and Construction (AEC) Industry—A Bibliometric—Qualitative Literature Review of Research Activities. *International Journal of Environmental Research and Public Health*.

Maxwell, L., & McCain, T. (1997). Gateway or gatekeeper: the implications of copyright and digitalization on education. *Commun. Educ. 46(3)*, 141–157.

McFarland, D. a. (2006). Adding contextual specificity to the technology acceptance model. *Computers in Human Behaviour*, 427-447.

McKinsey & Company. (2020). *How COVID-19 has pushed companies over the technology tipping point—and transformed business forever*. Chicago: McKinsey & Company.

Mendes, L. (2020). How can we quarantine without a home? Responses of activism and urban social movements in times of COVID-19 pandemic crisis in Lisbon. . *Tijdschrift voor Economische en Sociale Geografie*, 111,318-332.

Moon, N., Baker, P., Roy, R., & Bozzorg, A. (2014). "Disability issues and planning education: findings from a longitudinal survey of planning programs and lessons for urban e-planning". *International Journal of E-Planning Research (IJEPR), Vol. 3 No. 3*, 38-52.

MPED. (2020). *Egypt Vision 2030*. Cairo: Ministry of Planning and Economic Development.

Nafrees, A., Ponnampalam, P., Razeeth, M., Kariapper, A., & Samsudeen, S. (2022). Smart Technologies to Reduce the Spreading of COVID-19: A Survey Study. *Proceedings of the International Conference on Intelligent Vision and Computing (ICIVC 2021)*.

Nasution, R., Rusnandi, L., Qodariah, E., Arnita, D., & Windasari, N. (2018). The Evaluation of Digital Readiness Concept: Existing Models and

Future Directions. *The Asian Journal of Technology Management Vol. 11 No. 2*, 94-117.

NBS. (2018). Digital transformation in Architecture . *RIBA, MICROSOFT Corporation*.

Newman, D. (2018, May 21). Retrieved from Forbes: https://www.forbes.com/sites/danielnewman/2018/05/21/understanding-the-six-pillars-of-digital-transformation-beyond-tech/?sh=22ad07893f3b

OECD . (2020, July 23). *Tackling Coronavirus (COVID-19) - Contributing to global effort - Cities policy responses*. Retrieved from https://www.oecd.org/

Ogbevoen, L. (2020). *What is Digital Readiness?* NY, USA: Oden technologies Company.

Parasuraman, A. (2000). Technology readiness index (tri) a multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research, 2*, 307-320.

Parasuraman, A., & Colby, C. (2015). An Updated and Streamlined Technology Readiness Index: TRI 2.0. *Journal of Service Research*, 1-16.

Philipp, R. (2020). Digital readiness index assessment towards smart port development. *Nachhaltigkeits Managemen Forum*, 28:49–60.

Philipp, R., Gerlitz, L., & Moldabekova, A. (2020). Small and medium-sized seaports on the digital track: tracing digitalisation across the south baltic region by innovative auditing procedures. In b. r. Kabashkin I, Y. I. Kabashkin I, & R. a. 2019. Cham: Springer. Retrieved from https://doi.org/10.1007/978-3-030-44610-9_35

Poirier, E., Staub-French, S., & Forgues, D. (2015). *Embedded contexts of innovation. Constr Innov15(1)*. 42–65.

Reeves, M., Fæste, L., Whitaker, K. and Hassan, F. . (2018). “The truth about corporate transformation”. *MIT Sloan Management Review, January 31, 2018*.

Reis, J., Amorim, M., Melão, N., & Matos, P. (2018). Digital transformation: a literature review and guidelines for future research. In Á. Rocha, H. Adeli, L. Reis, & S. Costanzo, *Trends and Advances in Information Systems and Technologies: WorldCIST 2018. AICS, vol. 745* (pp. 411–421). Cham: Springer.

Reis, J., Amorim, M., Melão, N., & Matos, P. (2018, March). Digital Transformation: A Literature Review and Guidelines for Future Research.

Reis, J., Amorim, M., Melão, N., Cohen, Y., & Rodrigues, M. (2020). Digitalization: A Literature Review and Research Agenda. *Proceedings on 25th International Joint Conference on Industrial Engineering and Operations Management – IJCIEOM (pp.443-456)*.

Scopus: Content Coverage Guide. (2017). *pp. 1–28*. Retrieved from https://www.elsevier.com/__data/assets/pdf_file/0007/69451/0597-Scopus-Content-Coverage-Guide-US-LETTER-v4-HI-singles-no-ticks.pdf

Simon, B. (2001). *Wissensmedien im Bildungssektor. Eine Akzeptanzuntersuchung an Hochschulen. (Doctoral dissertation)*. WU: Vienna University of Economics and Business.

Son, M., & Han, K. (2011). Beyond technology adoption: technology readiness effects on post-adoption behavior. *Journal of Business Research*, 64(11), 1178-1182.

Srai, J., & Lorentz, H. (2019). Developing design principles for the digitalisation of purchasing and supply management. *J. Purch. Supply Manag. 25(1)*, 78-98.

Syed, I. (2018). *Digital Transformation Journey*. Retrieved from https://www.linkedin.com/pulse/digital-transformation-journey-part-1-imad-syed/

Taherdoost, H. (2017). Determining sample size; how to calculate survey sample size. *International Journal of Economics and Management Systems, Vol. 2*, 237-239.

Talamo, C., & Bonanomi, M. (2020). *The Impact of Digitalization on Processes and Organizational Structures of Architecture and Engineering Firms*.

Toimah, A., & Afifi, S. (2019). “Introducing a conceptual framework for spatial decision SIM: a tool supports decisions for stakeholders". In H. V. Abusaada, *Handbook of Research on Digital Research Methods and Architectural Tools in Urban Planning and Design* (pp. 138-155). Hershey, PA: IGI Global.

UNESCO 1. (2021, February). Retrieved from Education responses: http://en.unesco.org/

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model, Four longitudinal field studies. *Management science, 46(2)*, 186-204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly*, 425-78.

Wang, M., Wang, C., Sepasgozar, S., & Zlatanova, S. (2020). A Systematic Review of Digital Technology Adoption in Off-Site Construction: Current Status and Future Direction towards Industry 4.0. *Buildings*, 10, 204.

Westerman, G., Calméjane, C., Bonnet, D., Ferraris, P., & McAfee, A. (2011). Digital Transformation: A Roadmap for Billion-Dollar Organizations. MIT Sloan Management, MIT Center for Digital Business and Capgemini Consulting.

World Health Organization. (2020). Retrieved from https://www.who.int/

Worldometer. (2022). *Worldometer*. Retrieved from https://www.worldometers.info/

Yin, R. (2014). *Case Study Research: Design and Methods*. *Sage Publications*.

Zaoui, F., & Souissi, N. (2020). *Roadmap for digital transformation: A literature review*. Procedia Computer Science-Elsevier-Online ISSN: 1877-0509.

Appendices

Appendix A: Interviews Questions

The format of the interview consists primarily of the following open-ended questions in the following order:

Q1: What is the first thing that comes to your mind after hearing the term DT?

Q2: When have you established/joined the office?

Q3: What digital technologies do you adopt in the office?

Q4: What is the motivation behind choosing such tools?

Q5: What is the Approach/Strategy of adopting such tools in your transformation journey?

Q6: Was it easy to integrate it within the processes?

Q7: What are the core differences before and after adopting and integrating these tools into business? Differences regarding "Cost/profit, Time, Employees readiness and acceptance, Collaboration internally and externally and with the clients"

Appendix B: Interviewees Profiles and Glimpse of Responses

Interview A: This interview has taken place with a 27-year-old interviewee who has his own business "a design office" and works also as a design architect to an employer in another office both at the same time. He established his office since 2019, it was born digital adopting certain digital technology tools in design process such as BIM, Cloud computing, CAD, Rhino plus grasshopper and some mobile applications.

Since 2020, the team in the office have been doing market research, searching for a differentiator, which is a feature of your company or office that sets it apart from your most important competitors and gives you a perceived edge in the eyes of the people you are trying to attract as customers. The results of this research were that a number of offices get differentiated by cost, time or even the render quality, however these were common targets.

The interviewee is enthusiastic about gaming and Augmented Reality (AR). Subsequently, the interviewee has proposed a trial to his employer of using VR glasses in the design process as a sketching tool and integrate it with the whole package presenting and delivering to the client. It has been highly accepted and welcomed. As a result, the interviewee has integrated the VR glasses in two projects, and he is working on a third project in the time of writing this thesis.

Regarding the approach or the strategy of implementing and integrating such a tool, it has been mentioned that it is a trial for a process transformation following experimental approach, innovating by experiment. When asked about the ease of using a tool for him and for the other employees either in his office or the other office, it has been stated that he himself is eager to learn how to use it himself without even the need of any technical assistance just YouTube videos explaining the glasses and how it works as a design tool, for his work-mates they welcome the paradigm or the idea but nobody has even attempted to utilize it, let alone try to figure out how it functions or learn more about it, highlighting that there is an issue of rethinking how to radically start over or how to operate.

Talking with the interviewee about the core differences of projects before and after integrating the VR glasses, he has mentioned that it costs the client almost two thirds of the project total cost if he wants to have the project presented with the VR glasses, and regarding the time it has been stated that preparing a VR presentation takes time so to decrease the whole process time they use other rendering tools such as unreal engine for extended reality in the pre-requisites processes that are faster and gives satisfactory results.

Interview B: The second interview has taken place with an early forties' architectural office owner and head, a business owner who works as a university assistant professor as well. The office has been established officially since 2007, also born digital adopting and using several digital tools, for instance: Auto-CAD, Revit architecture, ArcGIS, 3ds-studio max, sketch up,

and Photoshop. Since 2017, they have started integrating Rhino and grasshopper software in the processes. It has been stated by the interviewee that the use of which tools depends on the client and the final product as well, mentioning that collaboration with the other disciplines is another issue. The interviewee also highlighted the importance of grasshopper in numerous projects as a problem-solving tool, extracting several different iterations by the auto generation aspect.

With a keen eye on everyday technology upgrades, as a business owner noticing the world integrating immersive technologies and AI in the architecture profession, the interviewee has started thinking of adopting VR-glasses in his office, since early 2022. The interviewee has declared that he finds the VR-glasses as tool mainly being used for art, interior design, for instance creating client or the user experience within a certain space. When asked about the approach or the strategy of this transformation initiative it has been mentioned that it is still under experiment, until it gives an indication or a proof of digital success.

Regarding the benefits and challenges of such a transformation initiative, the interviewee has clarified that he is expecting not seeing a profit before 5 years, however such a tool is an “Edge of Design” as quoted by him. He also has stated that a core challenge is that there is no time for training the employees to use new gadgets in parallel with the workflow, it requires patience from the business owner, claiming that the employee is a gear that should be placed in its right place with equipped with tools and suitable circumstances.

Clarifying that offices that seek competitions would look forward engaging such new technology tools as well as training availability and affordability for its employees. Highlighting the importance of a business plan with a clear strategy for such initiatives. So, it is a vision from the senior management in the first place.

Interview C: The third interview has taken place with an early forties project lead, Digital Fabrication Laboratory (Fab-Lab) head, and a university associate professor. At first when the interviewee been asked about what she has in mind after hearing the terminology "Digital Transformation", she claimed that the first thing comes to mind is the Egyptian vision of DT, the ICT 2030 agenda.

Talking about the Fab-Lab establishment, the interviewee has stated that it is still just a soft opening phase, the laboratory has started working since 2020, it was planned to be finally opened in 2022 but because of some issues they had to delay the opening till June 2023. The idea behind the establishment of such a laboratory is to be defined as a capacity building, offering trainings to university students, as well as external architects. Nowadays, the laboratory team is planning a business model in order to act not only as a training center that offers students for free technical support, but also to act as a consultancy unit to get profit in order to sustain and keep alive.

Regarding the tools the laboratory adopts, the interviewee has mentioned that they started with the ordinary manual fabrication tools, in collaboration with a Laser cutter, a CNC machine, three 3D-printing machines, and she also has mentioned that they have attached different simulation machines, Virtual Reality VR-glasses and scanners as well. However, the interviewee has claimed that these tools are used just for presenting a model, but she aims to change this in future by train the employees as well as trainee to use it for thinking in the design processes, for instance, checking structure joints by fabrication.

In the near future, the team plans to buy a Robotic arm with different nozzles that could print concrete/clay parts, it could also drill holes. The interviewee states that the robotic arm would be an extraordinary move and transformation to the Fab-Lab.

Moreover, digging deeper with the interviewee about the approach and strategy of purchasing these tools, the interviewee has declared that starting this laboratory in the beginning was to solve a gap between the education phase and the professional phase, and it acts as an R&D department with experimental approach towards innovation. Fab-Lab also has funds that are distributed among the training sessions that is called Training of Trainers (TOT) and buying the tools.

Furthermore, exploring and investigating the core challenges they face, it has been declared that the financial resources, the internet connection, and speed as most of the work is done on the cloud, the place is other thing that Fab-Lab considers as a challenge, so they work in a temporary place until they could have another permanent larger space that fit the tools they have as well as an attached outdoor area that they could apply 1:1 scale models.

Ending this interview with a question regarding the profits, benefits, and gains in the contrary with the huge cost the pay for adopting fabrication tools and software, the interviewee has answered that they are on their way of transformation, adopting several tools that could de different operations and they are on track to be a consultancy unit to have more clients and profit out of this laboratory initiative, as there is a few fab-labs in education but none in professional life which is a differentiator and is clearly visible online and offline to the market.

Interview D: The fourth interview has taken place with a 26-year-old landscape architect, who works for an Egyptian office. Starting this interview by asking the interviewee about what she has in mind regarding the term “Digital transformation”, she has stated that it is more of getting benefits from adopting new tools and integrating them into business. Regarding the new tools adopted in the office, she has highlighted Land F/X software. She has stated that this software works as a Lister that could save a lot of time searching for landscape elements and description on auto CAD. Having stated that the business owner and senior management try to have a clear strategy f

adopting these tools, a deep R&D is followed before adopting tools but in the contrary no pre-readiness assessments for employees take place.

Furthermore, exploring the core challenges for adopting this software, she has mentioned the high cost of buying the software as well as the version is limited to a certain number of users.

Interview E: The fifth interview has taken place with a 27-year-old urban designer who also works for a fabrication lab, regarding the tools the laboratory adopts, the interviewee has mentioned the ordinary manual fabrication tools, transforming, and expanding by adding a Laser cutter, a CNC machine, three 3D-printing machines, 3D-scanners as well as VR glasses. In regard to the approach of adopting these tools the interviewee has declared they follow experimental approach of adopting the tool until they find a gap and then they try to solve it either by further research on other tools to be integrated or training for users.

Investigating the core challenges, the interviewee has stated some administrative issues, as well as the internet connection and speed. On the other hand, he stated that the understanding senior management and the employees' acceptance are core success leading factors which give indication to future profits.

Appendix C: Questionnaire List of Questions

Questionnaire Link:
https://docs.google.com/forms/d/e/1FAIpQLScHmYMV_azDR7G-4AnK8vREo50tS2VkY3X47KKpOPLw-WEXCQ/viewform?usp=sf_link

Digital Transformation

Terms and Conditions:
You are invited to participate in this questionnaire, and you should only participate if you want to; choosing not to take part will not disadvantage you in any way.

This questionnaire is a part of a research project that examines the technology acceptance to the Egyptian architectural engineers working in technical offices.
Questionnaire Structure:
It is a 10-15 minutes questionnaire consists of 14 questions that are divided into two main sections: one for general/personal information and the other regarding the research objective.

Contact and Connection:
If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact the researcher at: Sandy.grant@eng.asu.edu.eg
All the data that we collect will be kept strictly confidential. You will not be able to be identified in any ensuing reports or publications and your answer will be identified by anonymous ID.

* Required

1. Q0: Do you accept to proceed with the questionnaire or not? *

   Mark only one oval.

   - ◯ I accept and I wish to proceed with the questionnaire *Skip to question 2*
   - ◯ I do not want to proceed with the questionnaire

2. Q1: What is your age? *

   Mark only one oval.

   - ◯ below 20
   - ◯ 20 - 35 *Skip to question 3*
   - ◯ 36 - 55 *Skip to question 3*
   - ◯ Above 55 *Skip to question 3*

Personal Information

3. Q2: What is your gender?

Mark only one oval.

- ◯ Male
- ◯ Female

4. Q3: Please select your knowledge area *

Check all that apply.

- ☐ Architecture
- ☐ Building technology
- ☐ Computational design
- ☐ Urban Planning
- ☐ Urban Design
- ☐ Landscape design
- ☐ Other: _____

5. Q4: Job description *

Mark only one oval.

- ◯ Employer/Business owner
- ◯ Employee
- ◯ Freelancer
- ◯ Other: _____

Digital Transformation (DT)	According to (Westerman, Calméjane, Bonnet, Ferraris, & McAfee, 2011) DT could be defined as the use of technology to completely enhance performance or reach of enterprises, however it is not just all about the adoption of a set of technologies. Rather, it is an essential transition in culture, aided and facilitated by technology.

6. Q5: What digital technologies are you using or planning to invest in each of the following? *

Mark only one oval per row.

	Using Now	Plan to use in the upcoming 3 to 5 years	Not sure if I will use in 3-5 years
Social Media	◯	◯	◯
Artificial Intelligence(AI) or machine learning	◯	◯	◯
Building Information Modelling (BIM)	◯	◯	◯
Digital collaboration tools (Online meeting software for instance Webex, zoom, Microsoft teams, shared documents docx, PPT..,etc)	◯	◯	◯
Smart digital assistants or 'bots'	◯	◯	◯
Internet of Things IoT (Sensors, communication networks)	◯	◯	◯
Immersive technologies (MR, AR, VR)	◯	◯	◯
Mobile/apps	◯	◯	◯
Cloud computing (including	◯	◯	◯

document management)

7. Q6: If digital transformation was a journey, where is your practice stand on that journey? *

Mark only one oval.

- ◯ We've not started yet
- ◯ We've started but we're at the beginning/early stages
- ◯ We've been on the journey for some time but it's not complete
- ◯ We're well on the way to completing the journey
- ◯ Not sure
- ◯ We've reached our destination

8. Q7: In your opinion, what are the main challenges for architectural practices and organizations that want to go digital and transform their business into one that is totally digital? *You may select more than one response from the following checklist. *

Check all that apply.

- ☐ Lack of digital skills company/offices-wide
- ☐ The cost of purchasing new software
- ☐ Slow decision making or excess cautions
- ☐ Lack of senior management commitment/sponsorship "Investment"
- ☐ it is difficult to know which digital trends or opportunities to respond to
- ☐ Unwillingness to radically/originally rethink how to operate
- ☐ Lack of IT Services/supply infrastructure & operation
- ☐ Too much focus on technology adoption and technical aspects over human readiness aspects
- ☐ Employees are being replaced by technology practices to adjust technological changes
- ☐ Resistance from contractors
- ☐ Resistance from clients
- ☐ Other:

9. Q8: How would you describe the main benefits of adopting/implementing digital technologies at your office? *You can choose more than one response from the following checklist* *

Check all that apply.

- [ ] Optimization of project efficiency (Final outcome)
- [ ] Optimization of internal business efficiency (For instance: communication)
- [ ] Time "Less time to do a job"
- [ ] Other: _____

10. Q9: By adopting or implementing digital technologies, what aspects of your work are being changed, or are likely to be changed? *

Mark only one oval per row.

	Changed/changing now	Likely to change in next 1 – 2 years	Likely to change in next 3 to 5 years	Not changed, and not likely to change	Not sure
Presenting designs to clients	◯	◯	◯	◯	◯
Client communication	◯	◯	◯	◯	◯
Collaboration – internally	◯	◯	◯	◯	◯
Collaboration – externally	◯	◯	◯	◯	◯
Clash detection	◯	◯	◯	◯	◯
Making decisions on site	◯	◯	◯	◯	◯

11. Q10: In what ways are you/your organization/office leveraging digital technologies? *You can choose more than one response from the following checklist* *

Check all that apply.

- [ ] Improving employee collaboration and productivity
- [ ] Creating new/ better customer experiences using digital technologies
- [ ] Other: _____

12. Q11: Please state whether or not you agree with these statements. *

Mark only one oval per row.

	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree
Digital technologies are transforming the way we work now in a positive way	◯	◯	◯	◯	◯
Digital technologies are transforming the whole construction industry	◯	◯	◯	◯	◯
Architectural practices who do not adopt digital ways of working will go out of business	◯	◯	◯	◯	◯
Our organization/Office has a digitally literate senior leadership team	◯	◯	◯	◯	◯
Our organization/Office has a clear or formal digital transformation strategy	◯	◯	◯	◯	◯

13. Q12: Check one or more of what you see as an impact of digital technology adoption! *

Check all that apply.

- [ ] a driver of efficiency
- [ ] raise more concerns about privacy and security
- [ ] a force for good - Positive Transformation
- [ ] older generations of workers will get left behind
- [ ] widen the divide in society between the 'haves' and 'have-nots' - Segregation and discrimination
- [ ] generate resistance from employees
- [ ] Very little – it's just the latest fad and will soon be surpassed by another trend/ buzzword
- [ ] Other: _____

14. Q13: What do you think are the largest shifts of techno-driven approach "Using Smart technologies to keep the workflow stable" during the COVID-19 crisis that most likely to stick with us through the recovery? *You can choose more than one response from the following checklist* *

Check all that apply.

- [ ] Increase in remote working/collaboration
- [ ] Increase clients demand for online services
- [ ] Increasing use of advanced modern technology in several operations
- [ ] Changing clients needs/expectations
- [ ] Build redundancies into supply chain
- [ ] increased spending on data security
- [ ] Other: _____

15. Q14: Which of these statements do you agree with! *You can choose more than one response from the following checklist* *

Check all that apply.

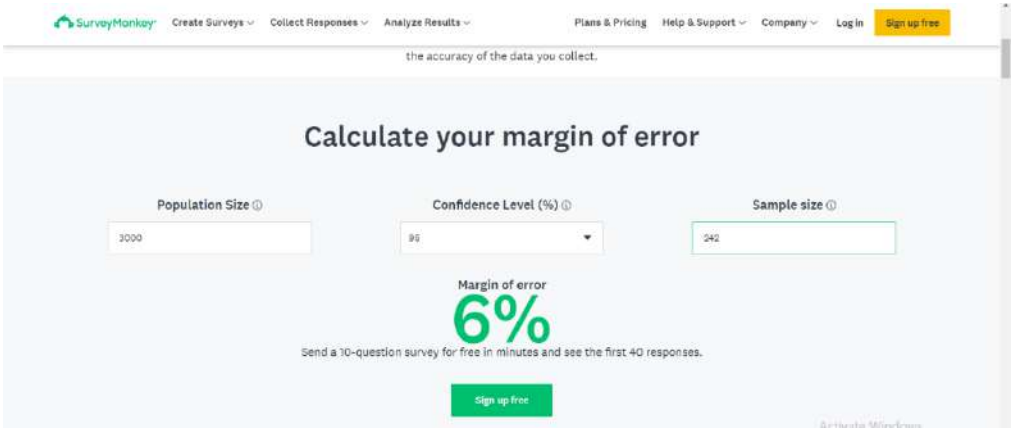
- [ ] Technology makes me more productive in my personal life
- [ ] Technology makes me more efficient in my occupation
- [ ] I do not consider it safe to do business online
- [ ] Communications technology and the Internet help people build stronger relationships
- [ ] Technology lowers the quality of relationships by reducing personal interaction
- [ ] Other people come to me for advice on new technologies
- [ ] When a new technology tool, gadget, or software is suggested, I need technical assistance.
- [ ] I am constantly updated with recent technology gadgets/tools
- [ ] I am not concerned with the digital technology tools/ prefer to stick to traditional methods
- [ ] Technology always seems to fail at the worst possible time
- [ ] I do not consider it safe to provide personal information over the Internet
- [ ] When I call a business, I prefer talking to a person rather than interacting with an automated system

Thank you!

Your participation is highly appreciated!

Appendix D: Survey Monkey Margin of Error / Sample Size Calculation

For Double checking the sample size and the margin of error.



ساندي جرانت

التحول الرقمي:
استعداد المعماريين في المكاتب التقنية المعمارية في مصر

ملخص
مع زيادة الاحتياج للتكنولوجيا في أواخر التسعينات، والانتشار الملحوظ للتقنيات الرقمية الجديدة، أصبحت الرقمنة هي التوجه الحديث. تحليل المسارات والأنواع والنهج لتبني التكنولوجيا الحديثة في العديد من المجالات كتحسين قائم على التكنولوجيا الرقمية في ممارسة الأعمال خاصة مهنة الهندسة المعمارية، إلى جانب الجائحة الصحية الغير مسبوقة لفيروس الكوفيد ١٩ و التى تعمل كمحفز للتحول الرقمي للحد من انتشار الفيروس. ولكن لم يتسأل أحد مسبقاً عن الاستعداد لمثل هذا التحول السريع و كيف يتقبل المعماريون وسائل التكنولوجيا الحديثة في عملهم.

لذلك يهدف هذا البحث للتحقق واكتشاف مدى استعداد المعماريون في المكاتب المعمارية في مصر للتحول الرقمي من خلال المنهجية التالية، البدء بالبحث المنهجي في أدبيات موضوع التحول الرقمي و شرح مختلف المصطلحات المتعلقة بالموضوع وتوضيح الفروقات بينهم، مع مسح لبعض الحالات العالمية والمحلية لاعتماد التكنولوجيا الرقمية الحديثة في مجال العمارة، أيضًا شرح و مناقشة مؤشر الاستعداد الرقمي ونظرية نموذج قبول التكنولوجيا لتكوين نموذج مشترك مجمع من النظريتين و استناداً لها سيقوم الباحث بتحديد معايير التقييم التي سيتم تصميم الاستبيان على أساسها ليتم نشره لأي معماري يعمل بمكتب هندسي لجمع تصورات مختلفة وتحليلها.

النتائج التي توصلت إليها الأطروحة من تحليل ومناقشة النتائج المستمدة من نتائج رسم الخرائط الببليومترية ونتائج الاستبيانات والمقابلات المترابطة مع دراسات الحالة. تساهم هذه الدراسة في اقتراح إطار وتوقعات لاعتماد التكنولوجيات في الشركات أو المنظمات أو المكاتب المعمارية.

الكلمات الرئيسة
الاستعداد الرقمي، قبول التكنولوجيا، التحول الرقمي في الهندسة المعمارية

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام. إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة ٢٠٢٢

هذا ويقر الباحث أن العمل المقدم هو خالصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كل في مكانه في مختلف أجزاء الرسالة.

وهذا إقرار مني بذلك،،،

التوقيع :

الباحث: **ساندي جرانت**

التاريخ: / /

التحول الرقمي:

استعداد المعماريين في المكاتب التقنية المعمارية في مصر

رسالة مقدمة للحصول على درجة ماجستير العلوم الهندسية في العمران المتكامل و التصميم المستدام

إعداد: **ساندي جرانت**

المشرفون:

أ.د عبير الشاطر
أستاذ التخطيط و التصميم العمراني
جامعة عين شمس

أ.م.د محمد عزالدين
أستاذ مساعد بقسم الهندسة المعمارية
جامعة عين شمس

لجنة الحكم **التوقيع**

أ.د
أستاذ
جامعة

أ.د
أستاذ
جامعة

أ.د
أستاذ
جامعة

تاريخ المناقشة: / /

الدرسات العليا

ختم الاجازة

موافقة مجلس الكلية: / /

أجيزت الرسالة بتاريخ: / /

موافقة مجلس الجامعة: / /

جامعة عين شمس

التاريخ: / /

جامعة عين شمس

التحول الرقمي:

استعداد المعماريين في المكاتب التقنية المعمارية في مصر

رسالة مقدمة للحصول على درجة ماجستير العلوم الهندسية في العمران المتكامل و التصميم المستدام

إعداد:

ساندي مجدي جرانت

المشرفون:

أ.د عبير الشاطر

أستاذ التخطيط و التصميم العمراني

جامعة عين شمس

أ.م.د محمد عزالدين

أستاذ مساعد بقسم الهندسة المعماري

جامعة عين شمس

٢٠٢٢