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Enhancing communication during the design process: A lean thinking approach

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ABSTRACT

This research aims to investigate the role of Lean Thinking (LT) in enhancing communication during the design process. To achieve the abovementioned aim, a research methodology consisting of a literature review, case studies and survey questionnaire was designed to accomplish four objectives. Firstly, building a comprehensive background about the research topic through reviewing the nature of the design process, causes and impacts of poor communication during the design process, and LT. Secondly, presenting and analysing three case studies to validate the identified causes of poor communications and to examine the role of LT in enhancing communication during the design process. Thirdly, assessing the perception and application of Architectural Design Firms (ADFs) in Egypt towards the role of LT in enhancing communication during the design process. Finally, proposing an LT framework to enhance communication during the design process. Data analysis showed that the highest-ranked methods of communication in ADFs were “face-to-face” and “3D shots”. In addition, “unclear communication channels and responsibilities” and “poor communication management” was ranked the highest causes of poor communication during the design process, while “disputes between the client and the architects”, and “poor understanding of the client requirements” were ranked the highest impacts of poor communication. Furthermore, the LT principles that have the highest rank were “identifying client’s value” and “improving the workflow”. This research proposed a practical framework that can provide a roadmap to assist ADFs in integrating LT principles as an approach for enhancing communication during the design process.

Keywords: Communication, design process, lean thinking, architecture design firms.

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INTRODUCTION

The construction industry plays an important role in the achievement of social and economic development objectives of countries worldwide (Olanrewaju et al., 2017). However, it is riddled with complexities and challenges. People with different cultures, objectives and professions collaborate in different manners to reach the main goal of project success (Gamil and Abdul Rahman, 2017). One of the main challenges of a construction project is poor communication occurred especially during the design process (Raymond, 2013). This is because the decisions made during the design process affect the building's performance throughout its life cycle. Communication is a crucial and dynamic process that aims to create an environment to exchange information and transform the client's needs and end-users requirements into technical drawings and specifications. This could be achieved by using various communication means including verbal, non-verbal, written, visual, and computer-generated designs and documentation (Norouzi et al., 2015). Communication has become more problematic during the design process because of the increasing requirements of clients and project stakeholders, the complexity of projects’ design, advancement of building technology and information management systems (Othman et al., 2004). Furthermore, Barrett and Stanley (1999) noted that relatively few structures are completed on schedule or at the proper price, and clients frequently complain that the

finished building is not what they expected. Clients, particularly inexperienced ones, may find it challenging to articulate their aims and operations to a third party, resulting in a confusing and inadequate project brief. When the designer is not proficient in the art of questioning, this becomes a bigger issue. Furthermore, a lack of presentation and visualisation tools hinders the client's understanding of the project design and how the building will look like. It appears that there is a lack of communication between the parties engaged at one or more phases of the construction process. LT is perceived as an effective strategy and well-tested platform for enhancing communication during the design process, understating clients' value systems, and eliminating any causes of poor communication, ambiguity or misinterpretation of project requirements (Hansen and Olsson, 2011). Accordingly, this research aims to investigate the role of LT in enhancing communication during the design process.

LITERATURE REVIEW

Nature of the design process

Design is an inventive problem-solving approach that combines art and science to create unique and sustainable solutions. Architects can address problems in a variety of methods; nonetheless, they adhere to a predetermined sequence of steps or patterns to achieve the intended design from conception to completion. The design process for practically every project might be a deliberate or subconscious effort by the architects (Abo Wardah and Khalil, 2016). It depends on (1) collecting, organising, and analysing information to ensure their contribution to the project design, (2) testing the design solutions through the architect's analytical ability, intuitive, and personal experience and (3) evaluating the developed solutions to judge their suitability of resolving the design problem (Jones, 2015). Norouzi et al. (2015) stated that several studies have identified certain elements that help explain the communication between the architect and the client during the design process. At the beginning of each design brief, there is a significant lack of information accompanied by clients' frequent demand for high expectations. The client's requirements have to be properly understood to develop a design that meets the client's expectations. As the design progresses, the scope of the project expands and the lack of common ground and communication between the client and architect begins to arise due to several causes such as a language barrier, lack of experience and lack of effort to perceive the client's business case. Moreover, architects are not making enough effort to keep clients connected to the progress of their projects and tend to behave unilaterally. Finally, project solutions are primarily dependent on subjective factors originating from the client's requirements (Othman et al., 2004).

Stages of the design process

The usual project life cycle has seven stages, according to the Royal Institute of British Architects' plan of work update. Each stage has its description, task scope, and participants. The pre-construction stages will be the subject of this study. This is because pre-construction establishes the framework for every successful construction project. Before putting a shovel in the ground, the project team should develop a communication strategy and thoroughly review all areas of the project. The feasibility analysis and constructability exercise are commonly produced based on the project scope, programme needs, and site restrictions. Furthermore, when the basic concept matures into the final documents, the budget implications of design decisions are evaluated. Collaboration between the design team and the construction manager ensures that the systems and components chosen will work as planned and optimise building performance. The pre-construction phase consists of four stages: (1) preparation and briefing, where the client approves the project brief and confirms that it can be accommodated on the project site, (2) concept design, where the architectural concept is approved by the client and aligned to the project brief, (3) spatial coordination, where the architectural and engineering information is spatially coordinated, and (4) technical design, where all design information is coordinated (Royal Institute of British Architects-RIBA, 2020).

Communication during the design process

The design process, which is based on the client's needs and has a significant impact on the project's value, is the initial step of project implementation (Senescu et al., 2013). Communication is essential during the design process, and it is critical to communicate frequently between the architect and the client to avoid conflict by determining which messages and information should be sent by the right sender to the right recipient in the right manner via the right media (Kliem, 2008). To overcome difficulties during the project's early design phase, it is critical to understand the reasons and consequences of inadequate communication and to create a practical communication management system (Taleb et al., 2017).

Causes and impacts of poor communication during the design process

Ineffective communication between the architect and the client hindered the design process (Kitchens and Shiratuddin, 2007). The following discusses the reasons behind poor communication during the design phase:

Physical barriers (CPC1): These are the natural or

human-made factors that hinder the flow of communication between project participants. Examples of physical barriers include noise, poorly designed workplace, geographical distance, limited or different time zones, disturbance in mediums or technical issues (Norouzi et al., 2015). Physical barriers lead to a poor understanding of the client's requirements and disputes between the client and the architect (Enshassi et al., 2009; Gomez-Ferrer, 2017).

Linguistic barriers (CPC2): These are the language features that result in miscomprehension, lack of understanding or complete loss of communication. This could be caused by a variety of factors like differences in educational background, level of literacy and country of language user, and use of jargon to actual language. Because the architectural language consists of symbols and drawings, as a result, if clients understand it in their manner, it may result in misinterpretation and unsatisfactory teamwork (Hussain et al., 2018; Norouzi et al, 2015).

Cultural diversity barriers (CPC3): Thinking behaviour, cultural norms and values, stereotypes, beliefs, morals, motivations, priorities and body language and gestures are examples of cultural diversity barriers that occur between the client and the architect. These barriers could create a difficult environment for communication, and lead to client dissatisfaction, disputes and constant design changes (Othman and Fouda, 2021; Abdul Rahman et al., 2013).

Lack of honesty and integrity from the architect (CPC4): According to the Architect's Registration Board standards (ARB, 2009), architects have an ethical obligation, to be honest, and trustworthy in the execution of their professional responsibilities. A breach of this standard undermines public confidence in the profession and jeopardizes communication between the client and the architect. Examples of architects' dishonesty include placing their interests ahead of their clients, disregarding the client's role and acting independently, making false statements of material fact and altering the scope or objectives of the project without the client's consent (AIA, 2020; Othman et al., 2004).

Poor feedback received from the client (CPC5): Architects understand that clients' constructive feedback is an essential part of the design process. However, sometimes poor feedback such as providing incomplete information, and delayed reply to the architect affects the communication between the client and architect and leads to a low productivity rate of the design team and time overrun of the design process (Enshassi et al., 2009; Abd El-Razek et al., 2008).

Work stress and pressure on the design team (CPC6): Architectural design is a creative and stressful process and architects are often responsible for meeting deadlines. Causes such as limited available design time, changing design requirements and having second thoughts at later stages (Othman et al., 2004) lead to pressure on the design team resulting in personal errors, and incorrect or inaccurate outcomes. People working under pressure may be affected psychologically and physically which affects their relationship with clients (Hussain et al., 2018).

Poor communication management (CPC7): Most project managers quickly recognize the need for effective, clear communication that is suited to the client's needs. It has been argued that communication is essential to the success of any project and that the majority of project failures can be traced back to poor communication. Examples of poor communication management include inefficient information exchange, and a lack of linking the visions of the architect and the client (Gamil and Abdul Rahman, 2017) all of which affect the success of the project (Enshassi et al., 2009; Abd El-Razek et al., 2008).

Ineffective communication (CPC8): When communication is ineffective, it means that the method or results were insufficient. The two key elements that might lead to unsuccessful communication are time and quality.

Unclear communication channels and responsibilities (CPC9): Communication suffers as a result of unclear routes of communication that present several challenges to both sender and recipient. To prevent message transmission and delivery failure, stakeholders must establish a mutually agreed-upon path. Inadequate communication and a lack of information sharing are other results of the project team's failure to define their roles.

Poor stakeholders' identification (CPC10): Because they are not properly identified inside the project, stakeholders run the risk of information reaching the wrong person. Due to their lack of involvement in the project, stakeholders may, in extreme situations, not get any information. Stakeholders must be recognized at the project's outset and as they get involved (Pérez Gómez-Ferrer, 2017).

Inexperienced stakeholders and architects (CPC11): If inexperienced stakeholders are not handled properly, they might offer an obvious threat. Hesitation and fear of making mistakes can have a direct impact on the quality and timeliness of their activities and reactions to the information supplied. In addition, inexperienced architects will not be able to understand the client's needs or extract project requirements from the client as well as identify the project business case.

Multi-organizational interactions (CPC12): One of the

most challenging challenges is inter-organizational contact, which necessitates planning and management throughout the whole project. When several organizations are involved in the communication process, some various senders and recipients frequently need enormous volumes of information at the same time.

Technology malfunctions (CPC13): In today's technology-dependent culture, communication suffers directly from technological failures. Technology is routinely used to spread information, especially where the distance between stakeholders is a concern.

The complexity of the construction project (CPC14): Due to the need for participation from several organizations and the complexity of the construction project, complex communication procedures will arise to effectively finish the project. The stakeholder relationships may be highly complex, and a lot of complex information is shared during the project.

Inadequate support for the use of communication technologies (CPC15): Insufficient support for the use of communication technologies may complicate rather than simplify the communication process. Communication technology is a tool that should allow stakeholders to transmit detailed information quickly. Technical support must be available to teach stakeholders how to use this modern tool efficiently.

Lean thinking

LT is the process of making business decisions in a Lean way. It is regarded as the foundation of any Lean practice. LT has been recognized as a successful technique for mass manufacturing, resulting in maximising value, and reducing waste, cost and time while also boosting market competitiveness (Hansen and Olsson, 2011). According to Emmitt et al. (2004), LT should be implemented as soon as possible throughout the project life cycle. LT principles are as follows:

Lean thinking principles

LT has five basic principles that were put in place to solve the myriad issues that arise as a consequence of differences in corporate culture and management thought processes.

Identifying the client's value: This principle aims to identify the value from the client's perspective. Value is the optimum achievement of the required functions that meet the clients' and users' needs, desires and expectations in a way that protects the environment, enhances society and prospers the economy (Othman, 2007). Value is what the customer is willing to pay for. It is paramount to identify stakeholders and discover their actual or latent needs through quantitative and qualitative techniques such as interviews, and surveys.

Understanding the value stream: This principle aims to understand the value stream. It focused on perceiving the activities that add value to the design's development (Hines et al., 2004). The principle encourages companies to identify and maximize all activities that add value to the project, automating the supporting activities and removing non-value-adding activities (Duggan, 2012).

Improving the flow of work: This principle focuses on enhancing the workflow in value-added operations after eliminating any visible waste (Lian and Landeghem, 2002). It tries to reduce the amount of time that information takes to reach the customer. This can be accomplished by distributing the workload equally among the architects (Liker, 2004), creating a platform for communication to enable easy information exchange between the client and the architect (Varaksina, 2020), and properly encoding information such as architectural terms and other crucial information. The information conveyed must be open, clear, illustrative, and understandable (Gifu and Teodorescu, 2014).

Adopting the pull strategy: This guideline seeks to ensure that clients receive the desired design at the time they want it. An architect should be able to manage when and what information is supplied to him when using the pull technique to regulate the flow of information. In addition, the architect should give the information to the customer at the proper time when required (Thangarajoo and Smith, 2015).

Pursuing perfection: This principle aims to seek perfection. This means constantly looking for ways to improve the production process and eliminate waste. One way to achieve perfection is through a continuous improvement process which allows businesses to continually identify and eliminate waste in their system. According to Emiliani (1998), firms will be able to accomplish perfection if the first four principles are implemented to a high degree which could be implemented through education and training.

Research gap and discussion

Design is a creative and complex process. It involves various participants with diverse cultures, objectives and professions who interact in many ways to achieve the objectives of the project. Communication is a crucial and dynamic process that aims to create an environment to exchange information and transform the client's needs and end-users requirements into engineering drawings

and technical specifications. However, one of the most challenging factors of the design process is the poor communication between the project participants. During this research the causes and impacts of poor communications during the different stages of the design process were identified and discussed (Table 1). Without overcoming these causes, the project design will encounter many challenges. Despite the various communication means used to enhance the communication process, LT is perceived as an effective strategy and well-tested platform for enhancing communication during the design process (Table 2).

Table 1. The relationship between causes and impacts of poor communication and stages of the design process (Developed by the Authors).

Causes of poor communication during the design process	Stages of the design process					Poor communication Impact during the design Process												
	Strategic Definition	Preparation and Briefing	Concept Design	Spatial Coordination	Technical Design	Project Failure	Dispute between the client and the architect	Design over budget	Design time overrun	Poor design quality	Rework of project design	Poor collaboration between the client and the architect	Untimely reactions	Low productivity rate	Poor understanding of client requirements	Design mistakes and errors	Unsatisfied client	Client's constant design changes
(CPC01)	■	■													■			
(CPC02)															■	■		
(CPC03)	■	■	■	■	■		■				■	■						
(CPC04)		■		■		■	■	■			■						■	
(CPC05)			■	■					■		■							
(CPC06)				■	■					■				■		■		
(CPC07)			■	■	■	■	■		■									
(CPC08)		■	■				■					■			■			
(CPC09)		■		■								■						■
(CPC10)			■	■	■					■		■		■				
(CPC11)	■	■	■						■						■			■
(CPC12)			■	■	■		■								■		■	
(CPC13)		■	■				■						■			■		
(CPC14)			■	■	■					■	■		■				■	
(CPC15)		■	■				■						■			■		

RESEARCH METHODOLOGY

Achieving the research aim called for a research strategy that could gather data sufficiently rich to develop the abovementioned framework. Two approaches, namely, theoretical (literature review) and practical (field studies), were used to achieve four objectives:

• First, the literature review was used to build a comprehensive background about the research topic by reviewing the nature of the design process, causes and impacts of poor communication during the design process, and LT.

• Second, three case studies were collected and analysed to validate the identified causes of poor communication during the design process and to investigate the role of LT in enhancing communication during the design process. According to Yin (2002), the design of the case studies was based on cohesive and consistent components of the research questions,

Table 2. The relationship between causes of poor communication during the design process and LT principles (Developed by the Authors).

Causes of poor communication during the design process	LT principles: Identifying client's value		Understanding the value stream		Improving the flow of work		Adopting the pull strategy		Pursuing perfection	
	Defining value from the client	Use only reliable, thoroughly tested technology	Align design to quality	Respect Preferred Modes of communication	Level out the workload	Develop a communication platform	Encoding of knowledge like certain architectural terms	Repeat the information that was received to ensure correct understanding	Delivering information as soon as it was requested	Training
(CPC01)						■				
(CPC02)								■		
(CPC03)							■			
(CPC04)			■							
(CPC05)									■	
(CPC06)					■					
(CPC07)						■				
(CPC08)						■				
(CPC09)				■						
(CPC10)						■				
(CPC11)	■									
(CPC12)							■			
(CPC13)										■
(CPC14)		■							■	
(CPC15)										■

objectives, propositions, analysis approach and the logic linking the data to the propositions and the criteria for interpreting the findings.

• Thirdly, a survey questionnaire was conducted with a representative sample of ADFs in Egypt to investigate their perception and application of LT towards enhancing communication between the client and architect during the design process. The survey consisted of open-ended questions (e.g. thoughts and opinions) and close-ended questions (e.g. Yes/No questions, rating questions based on a 1-5 Likert scale). A pilot study of the survey was tested with colleagues to determine its effectiveness and problems. After going over the responses to the preliminary test and making changes, the questionnaire was ready for formal testing (Baker, 1994; Czaja and Blair, 1996).

• Finally, based on the above, the research developed an LT framework to improve the communication between the client and architect during the design process (Figure 1).

Population and sampling

The sampling plan for the survey questionnaire using a random probability sampling method was applied to the population size which was 44 ADFs registered in the Egyptian Engineers Syndicate (EES, 2019). This allowed every unit an equal chance of being included in the sample (Hannagan, 1986). This helped to select a representative and non-biased sample. To calculate the sample size, the next two equations were used (Fluid Surveys Team, 2014).

$$\text{Sample Size Calculation} = \frac{\text{Distribution of } 50\%}{\left[\text{Margin of error\%} / \text{Confidence Level Score}\right]^2}$$

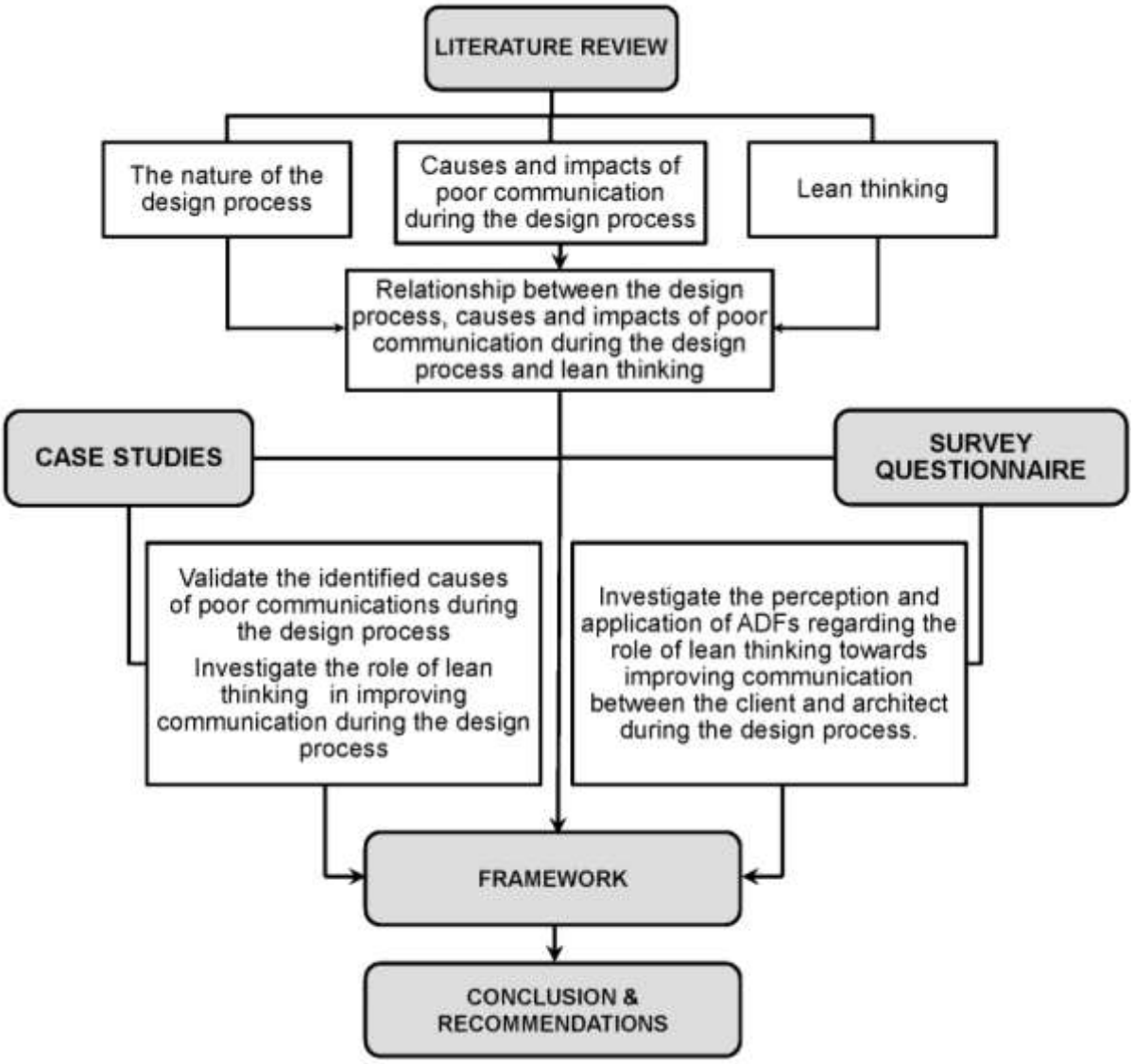

Figure 1. Research methodology (developed by authors).

$$\text{True Sample} = \frac{\text{Sample Size} \times \text{Population}}{\text{Sample Size} + \text{Population} - 1}$$

In this research, the confidence level chosen is 95% and the margin of error is 5%. The confidence level score corresponding to the confidence level of 95% is 1.96.

$$\text{Sample Size} = \frac{0.5 \times (1 - 0.5)}{\left[{}^{0.05}/_{1.96}\right]^2} = 384.16$$

$$\text{True Sample} = \frac{384.16 \times 44}{384.16 + 44 - 1} = 39.57 \sim 40$$

However, since the true sample size is only different from the population size by 4; the population size would be considered entirely for the survey questionnaire. It is worth mentioning that the names of these design firms were suppressed for security according to their request.

CASE STUDIES

Definition and selection criteria

A case study is a research method that is used to describe and analyse an individual matter, phenomenon, event, or project to identify variables, structures, forms, and orders of interaction between the participants in the situation or to evaluate work performance or development progress (Sturman, 1997). For this study, three case studies were selected and analysed. The case study

selection criteria were based on the nature of the selected project, data availability, degree of success, location and region. All of the case studies featured construction projects with different scopes that were successful in varying degrees to overcome the causes of poor communication during the design process. Because the topic received scant attention in construction literature, especially in the design process, there were few published case studies that addressed the discussed topic, and the availability of data was a major factor in selecting the case studies. Although the field study was conducted in Egypt, the case studies were chosen from other countries due to a lack of case availability in Egypt.

Case study (1): College of Business, Kuwait University, Kuwait

In collaboration with Cambridge Seven Associates, Inc., Kuwait University has assigned Gulf Consult (GC) as their resident consultant in their College of Business. Poor communication was evident during the design process, fortunately, GC was fast to define and solve the problem. GC management conducted an unstructured interview with the design team to identify the causes behind poor communication. These causes were identified as a lack of project information provided to stakeholders, lack of design team experience, unclear language of communication between the client and the design team, and poor identification of stakeholders. GC developed a list of LT activities and solutions to overcome the causes of poor communication and to prevent the occurrence of any other causes in the future. These solutions included “Identifying client’s value” which was achieved through defining project stakeholders clearly at an early stage of the project life cycle as well as their positions and responsibilities, “Understanding the value stream” through focusing on the value-adding activities such as conducting regular staff meetings to keep project participants informed and assigning tasks to competent staff members, “Improving the flow of work” through creating clear communication channels, guidelines, networks and upgrading them when required to ensure the flow of information, “Seeking perfection” was attained through monitoring and controlling the communication process regularly (Mossad et al., 2022).

Case Study (2): Istanbul grand airport, Turkey

Istanbul grand airport (IGA) is an extremely complex project which was built to operate Istanbul Airport for 25 years. It has a total area of 76.5 million m^2 with a budget of 12 million USD. Various national and international companies were involved in the design and construction of the project. That is why communication, collaboration and coordination among them required a structured and holistic approach. Thus, the integrated BIM with LT perspective was the methodology adopted to deliver the project successfully. The interactive BIM model was used as the platform for designing, incorporating, and recording design and development details. BIM implementation in the IGA project during the design and engineering phases provided a shared simulated world for all parties involved in the process. This is made possible by data sharing procedures through cloud-based data management software, as well as the creation of BIM models with required engineering decisions by incorporating various types of design knowledge. On a regular and weekly basis, the IGA BIM team usually held meetings to realise and define each important assignment, workflow, and implementation plan schedule of the IGA construction. The strategic benefits of these meetings are defined as coordination and workflow between all disciplines, as well as regular, weekly, and monthly checks and quality controls. The quality of the design product was improved by applying these implementations. During the design process, the collaborative clash detection helped ensure that all participants are synchronised. As a result, produced construction documents were updated in terms of potential clashes on site to prevent any on-site rework. In addition, other benefits were gleaned through the application of LT tools including delivering the project on budget, correct and high predictability, high rate of production, high level of profit and easy flow of information (Koseoglu et al., 2018).

Case study (3): The New Hospital Project, Canada

The New Hospital is a massive construction project in Quebec, Canada, with an estimated cost of CAD 1.97 billion. This hospital will combine the activities of two existing Quebec hospitals to simplify access to existing care management systems, align and reduce the distance between different hospital services, and thus improve patient care quality. The complexity of this project stems not only from the need to construct new buildings with an area of 180,693 m^2 and renovate parts of existing buildings with an area of 27,492 m^2 but also from the need to maintain regular operations of the two operating hospitals. To address these concerns a Lean-led Design approach was established through a multidisciplinary consultation workshop that lasted several days and included project managers, professionals, clinical managers, Ministry of Health representatives, clinicians, and patients. Each workshop could last from one to five days. The various LT activities implemented in these workshops included: (1) developing a common project goal, (2) improving the flow of patients, staff, visitors, supplies, equipment, medication, and information, (3) identifying proximity and priority needs to reduce distances between different sectors by putting the

patient at the centre of the reflection, and (4) evaluating the proposed plans to identify the one to retain for the rest of the project. These lean activities aided in improving alignment between client needs and design solutions during project definition in a complex context. Furthermore, they emphasized the importance of early stakeholders' involvement and encouraged dialogue a communication between architects and end-users achieve a common understanding of the project goals (Chbaly and Brunet, 2022).

DATA ANALYSIS

This section presents and analyses the results of a survey questionnaire conducted with a representative sample of ADFs in Egypt to examine their perception and application of LT towards enhancing communication during the design process.

Response rate and respondents' profile

Only 32 out of 44 ADFs invited to participate in the study, responded to the survey questionnaire which represents 72.73%. 27 firms are sole proprietors and the rest are partnerships. The number of years of experience of these firms in the construction industry ranges from 5 to 50 years. They are involved in all types of projects including residential, commercial, medical, industrial, cultural, business, recreational and educational. The size of these firms ranges from 10-50 employees with architecture, engineering and construction backgrounds.

Methods of communication during the design process

All respondents mentioned that they are aware of the different methods of communication during the design process. 95% of respondents stated that face-to-face is the most commonly used method of communication with clients, followed by 3D Shots (93%) and reference photos (83%). This is because face-to-face contact facilitates the exchange of ideas, helps establish trust and boosts active participation. In addition, it enhances conflict resolution, provides clarity of conversation and saves time during the workday. However, due to the covid-19 pandemic, ADFs reduced the number of such meetings and opted for other methods such as messaging apps and video meetings which were ranked 66% and 58% receptively. Moreover, respondents stated that augmented reality and virtual reality technology was the least used methods due to their high cost of devices (Figure 2).

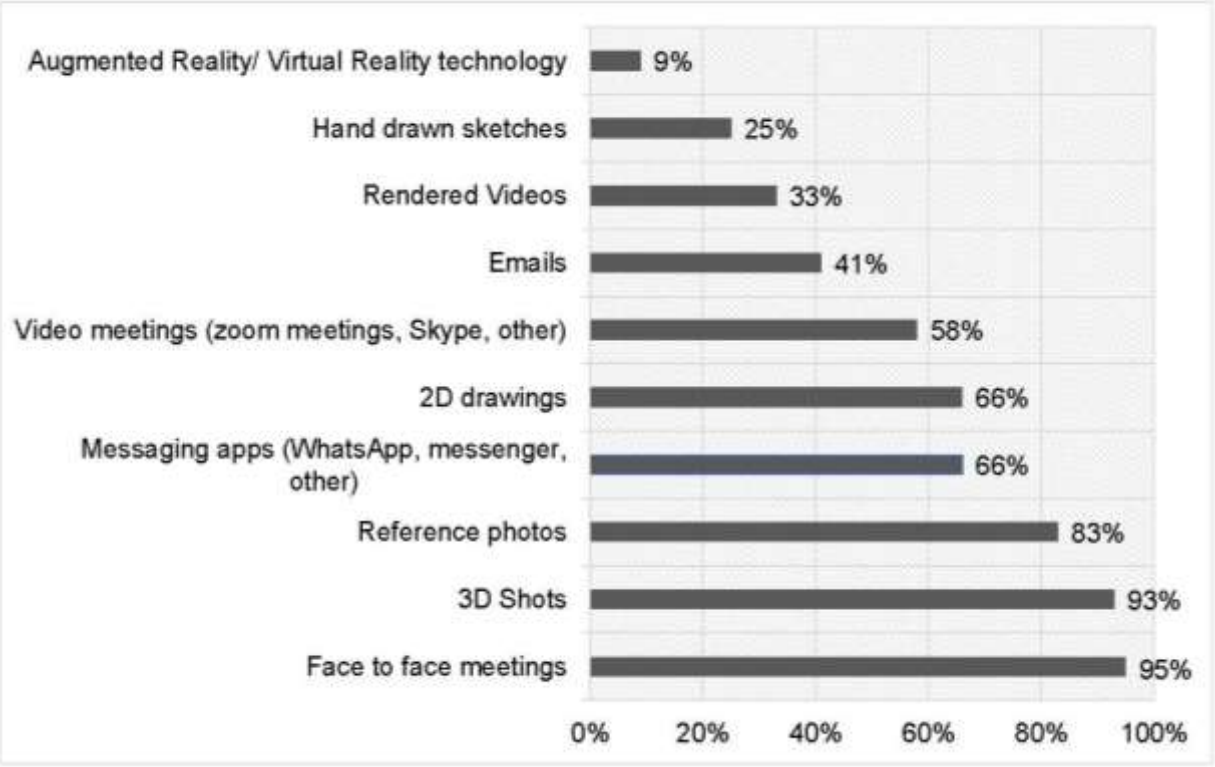

Figure 2. Respondents ranking of communication methods used during the design process (developed by the authors).

Causes and impacts of poor communication during the design process

Despite the importance of enhancing communication during the design process, the causes and impacts of poor communication persist. Respondents stated that "unclear communication channels and responsibilities" and "poor communication management" was ranked the highest causes of poor communication with percentages of 75 and 72%, respectively. This is because lack of identifying the routes and medium of information exchange, a lack of preparing proper communication plans and responsibilities at the early stages of the project life cycle as well poor linking between the visions of the architect and the client leads to poor communication, lack of information provision, design time overrun, design changes and disputes. 70% of respondents stated that "multi-organizational interactions" was ranked the 3rd highest cause of poor communication during the design process and 68% ranked "inexperienced stakeholders and architects" as the 4th cause. This is because the increasing number of involved organisations with different interests and objectives necessitates a large amount of information to share and more time for discussion. Moreover, unclear identification of project requirements and information provided as well as lack of the architect's experience to identify the client's business cases leads to poor communication, design errors mistakes and error and design changes. On the other hand, "physical barriers" and "technology malfunctions" were ranked the lowest causes with a percentage of 15.63% and 9.38% respectively. This could be referred back to the nature of communication with clients in ADFs which depends on face-to-face interaction (Figures 3 and 4).

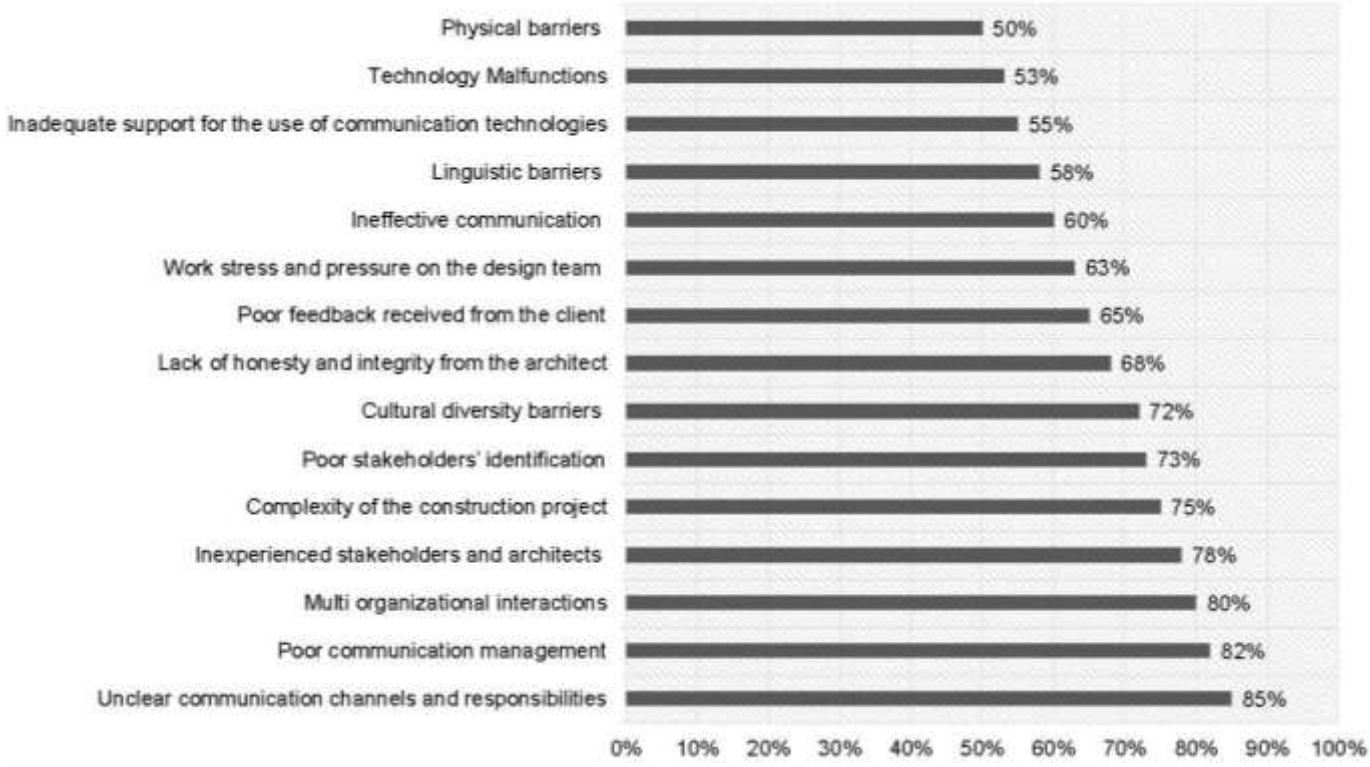

Figure 3. Respondents' ranking of causes of poor communication during the design process (developed by the authors).

Perception and application of LT towards enhancing communication during the design of ADFs in Egypt

According to 81.25% of respondents, LT could play an important role in enhancing communication during the design process. 60% of respondents stated that they are aware of the concept of LT and apply it during the design process. On the other hand, 40% of respondents mentioned that they apply LT principles without knowing they are called lean. This highlights the need to raise the awareness of ADFs towards the LT concept and its role in enhancing communication during the design process. These results are consistent with literature reviews by Othman et al. (2014) and Shaqour (2022), who concluded that lean concepts are employed in Egyptian construction projects during the design and construction

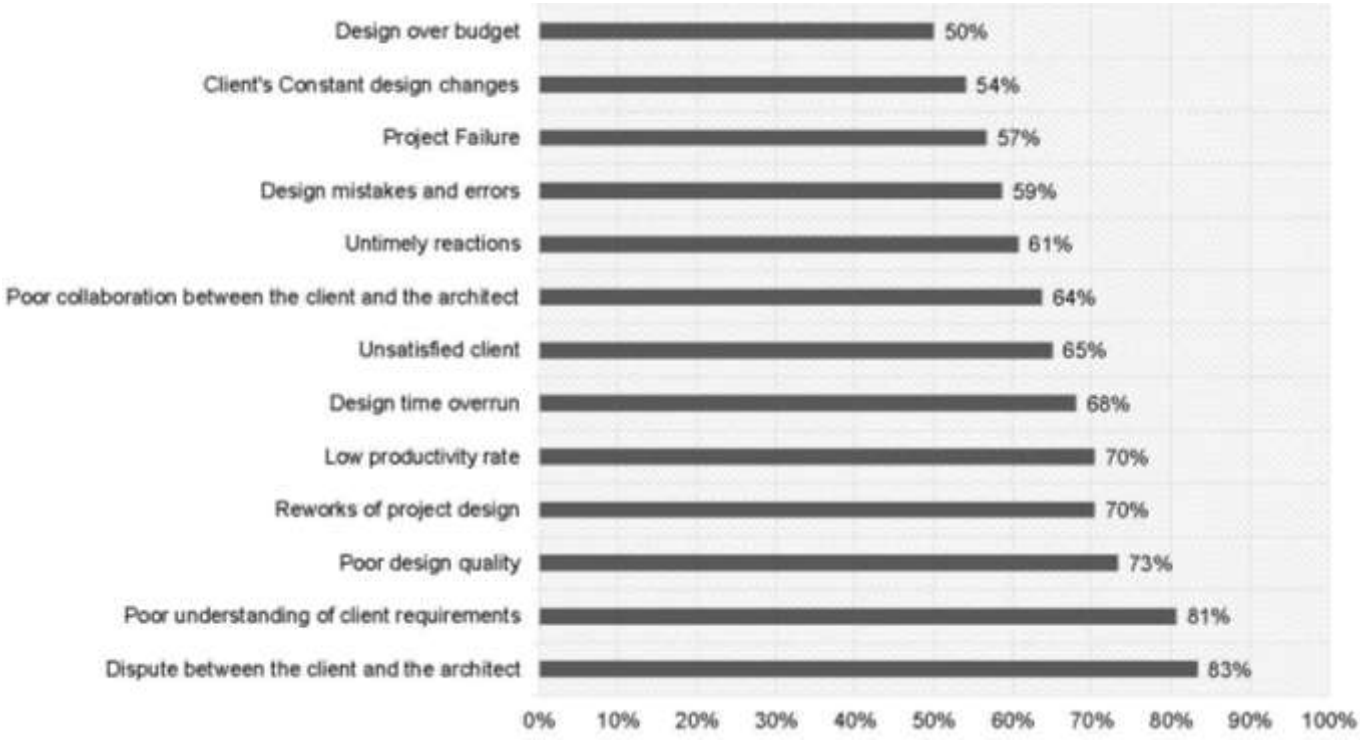

Figure 4. Respondents' ranking of impacts of poor communication during the design process (developed by the authors).

stages even if they are not known by that name. Respondents were asked to rank the LT principles adopted during the design process. Results showed that 84% of respondents stated that identifying the client's value is the highest-ranked principle, followed by improving the flow of work through developing a communication platform (75%) and pursuing perfection through offering training to architects (68%). This is because proper identification of project value from the client's perspective helps define the project's success factors. Moreover, enhancing the information flow increases communication between project participants and training programmes help enhance the skills of architects and deliver the client's value and enhance project performance (Figure 5).

LT-BASED FRAMEWORK FOR ENHANCING COMMUNICATION DURING THE DESIGN PROCESS

According to the results of the literature review, case studies and survey questionnaire, the research proposed the development of an LT framework for enhancing communication during the design process.

Definition and background

A framework is defined as a set of notions, techniques, and tools in a planned outline to complete a product, process and design (Engineering Data Management Service-EDMS, 2010). The LT Framework (hereinafter referred to as "the framework" or "LTF") is a proposed framework developed by this research to improve communication during the design process.

The need for the framework

The LTF is needed to provide a structured plan for senior management in ADFs to enhance communication between the project participants during the design process. The successful implementation of LT principles helps achieve the client's intended values, improving the workflow, enhancing the quality and eliminating waste. The necessity of this framework stems from the importance to utilise the benefits of LT principles to enhance communication during the design process.

Development of the framework

The development of the framework was based on the results of the literature review, case studies and data analysis gleaned from the survey questionnaire. Firstly, literature reviews identified the causes and impacts of poor communication during the design process. In addition, it investigated the LT principles. Secondly, case

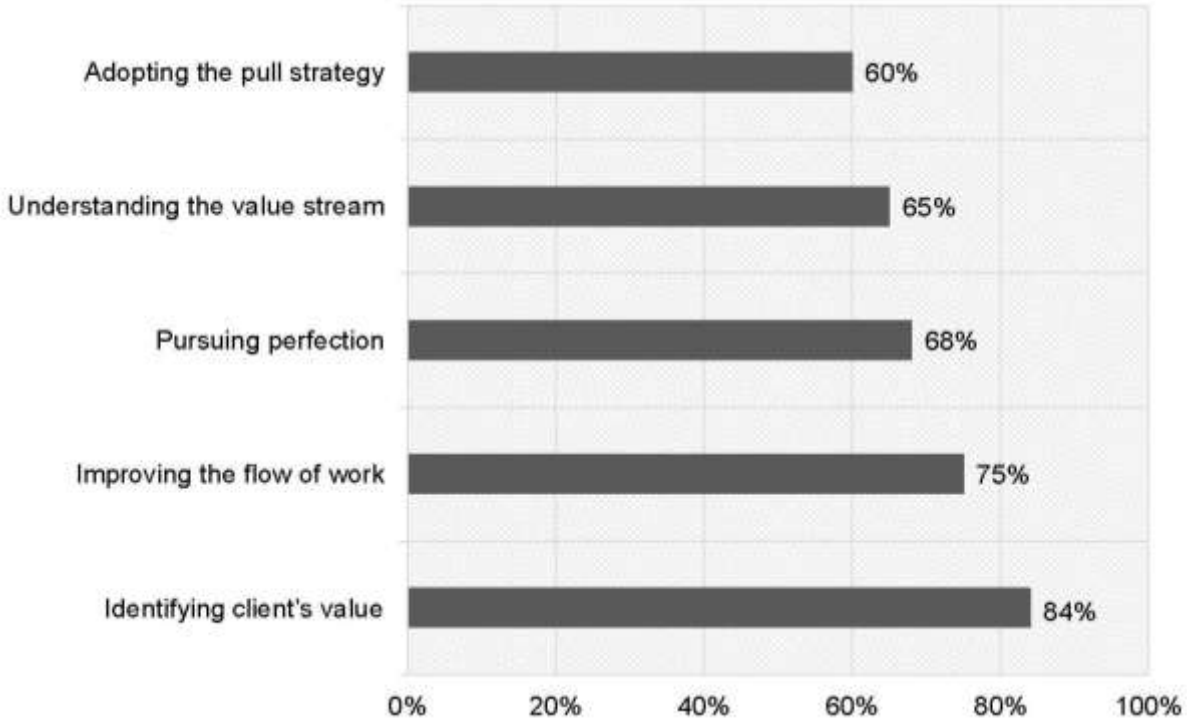

Figure 5. Respondents' ranking of the application of LT principles (developed by the author).

studies showed that ADFs that adopted LT principles succeeded in enhancing communication during the design process, while ADFs that did not adopt LT principles suffered from the causes and impacts of poor communication. Finally, the survey questionnaire ranked the causes and impacts of poor communication during the design process as well as investigated the perception of ADFs towards the role of LT in enhancing communication during the design process (Figure 6).

Aim of the framework

The LTF is an innovative conceptual business improvement tool designed to improve communication during the design process through the integration of LT principles.

The conceptual description of the framework

The framework consists of five functions, namely:

• Identifying communication problems.
• Establishing objectives and selecting appropriate LT principles.
• Developing LT integration plans.
• Executing LT integration plans.
• Monitoring and evaluating the integration plans (Figure 7).

Identifying communication problems

The "Identifying Communication Problem" function is an essential activity of this framework because it enables ADFs to identify the root causes of poor communication during the design process. It is of prime importance to build an effective team to carry out the intended study. Achieving a balance between the need for participants who represent various areas of expertise and possess diverse backgrounds is fundamental for accomplishing the study objectives. The study team should contain between six and twelve full-time participants to maintain optimum productivity (Norton and McElligott 1995). Performing an early orientation meeting will help in establishing strategic issues like study duration, resources required and assigning responsibilities to team members. Senior management support will facilitate the provision of needed resources and the adoption of study decisions and recommendations. Data collection methods (i.e. literature review, survey questionnaire, interviews and case studies) and data analysis techniques (i.e. quantitative and qualitative) have to be defined and utilised. Brainstorming techniques, team consensus and evaluation matrix have to be used for identifying the root causes and their impact on poor communication and rank them according to their importance. Based on the literature review conducted in this research, the causes of poor communication that ADFs may encounter could be classified as:

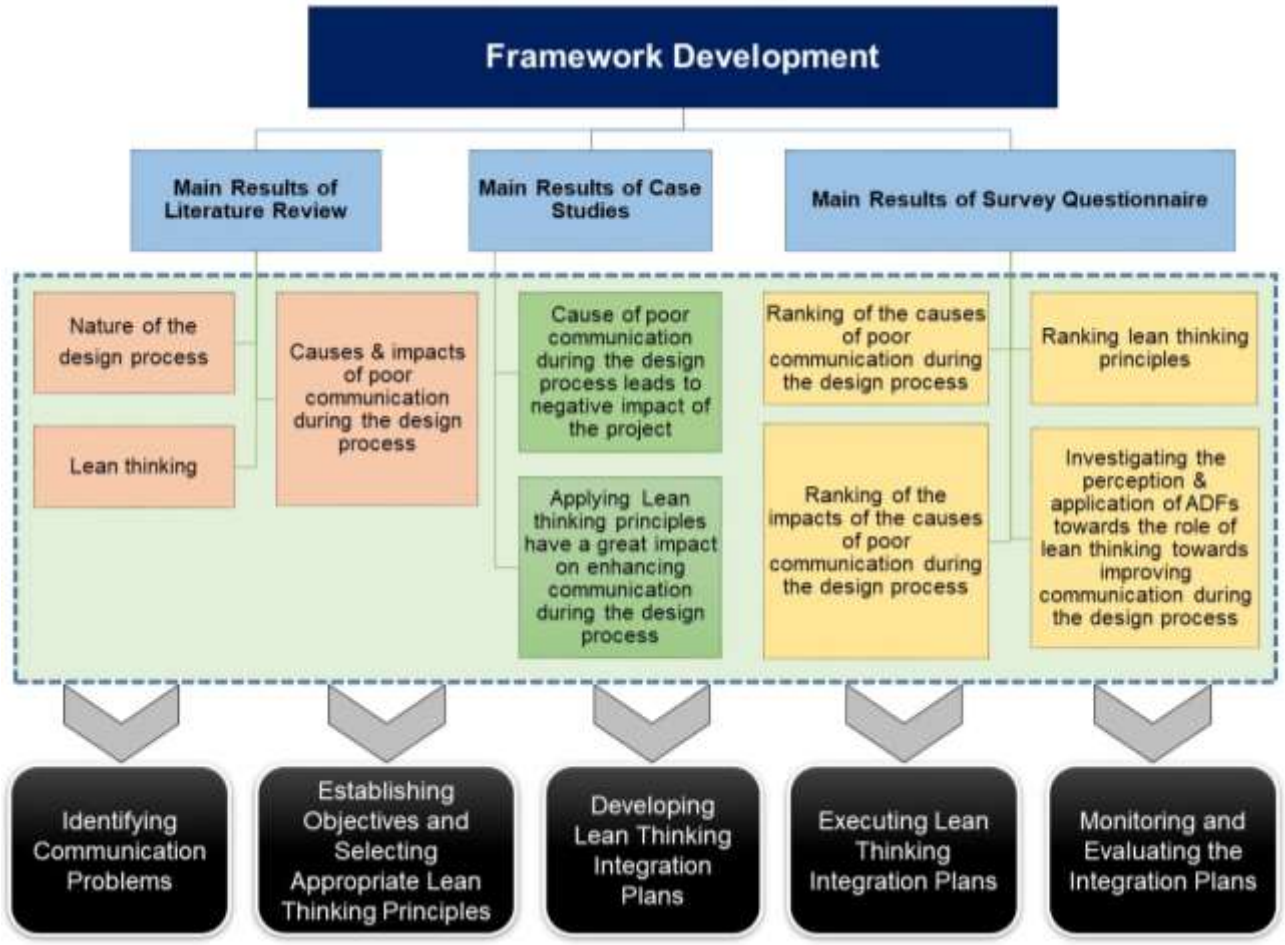

Figure 6. Framework development (developed by the authors).

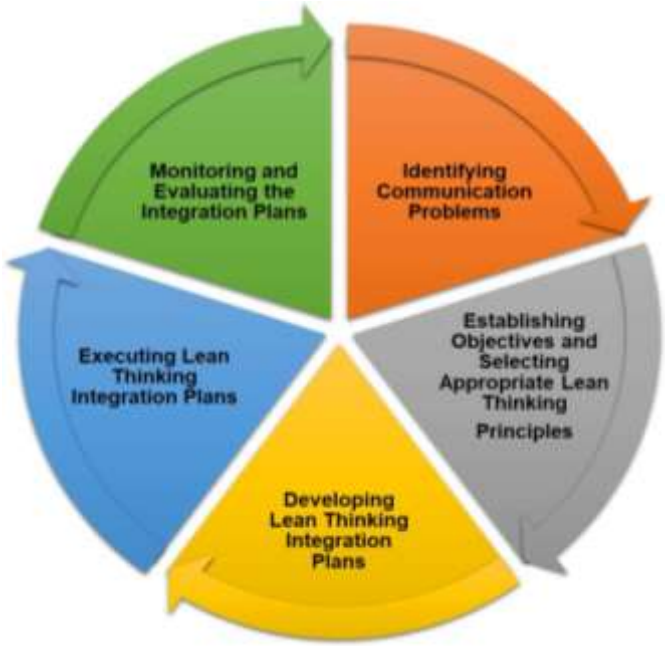

Figure 7. Functions of the LT framework.

• Integration, cooperation and human-related causes.
• Knowledge and experience skills related causes.
• Cultural and workplace-related causes.
• Technical and managerial-related causes.

Establishing objectives and selecting appropriate LT principles

Towards overcoming the causes of poor communication during the design process, the objectives of integrating LT principles have to be adequately established and agreed upon by all participants. This could be achieved through using brainstorming techniques and team consensus to generate and select objectives that address the identified problem. Establishing integration objectives and selecting the appropriate LT principle give team members ownership of these objectives and principles and encourages the study team to accomplish and apply them. An evaluation matrix will be used to rank these objectives and principles according to their significance. In addition, this function will result also in defining the criteria to be used to measure the success of integrating LT principles in the design process in ADFs in Egypt. The objectives of implementation could be:

• Increasing collaboration, communication, trust and transparency between the client and the design team.
• Improving project constructability through utilising the various experience of project participants.
• Enhancing the values delivered to the client and eliminating waste.
• Improving value stream mapping.
• Enhancing the flow of work.
• Increasing the quality of the delivered project.

Developing LT integration plans

The “Developing LT Integration Plans” function aims to set the procedures and actions necessary to accomplish the integration objectives. It will include a work breakdown structure and a responsibility matrix, where the first downsizes the work into manageable work packages and the latter links the activity to be done and the responsible person. In addition, the plans should include expected risks and corrective actions to be taken in case of the plan did not go as planned. Furthermore, the communication plan between the study team has to be developed to portray the reporting structure during the integration of LT principles into the design process in ADFs in Egypt.

Executing LT integration plans

Within this function, the plans developed in the previous function will be executed. The execution plans may require that employees involved in the integration process be trained and equipped with all tools and technologies required to guarantee the successful execution of plans. In addition, senior management support and offering the required facilities will help achieve the integration objectives. The execution function should use the work authorization system, which verifies the predecessor activities and permits the successor activities to proceed. This ensures the quality of work performed. This function will help overcome some of the causes of poor communication mentioned above such as inexperienced architects and inadequate support for the use of communication technologies.

Monitoring and evaluating the integration plans

This function aims to ensure that the integration of LT principles during the design process in ADFs in Egypt goes according to plans. Comments and feedback from the execution team will enable taking corrective actions if plans were not implemented as planned. Furthermore, this will help improve communication during the design process in ADFs in future improvement projects.

Benefits and limitations of the framework

The benefits of the framework will impact positively on enhancing communication during the design process in ADFs by overcoming the causes of poor communication. The benefits lie in providing ADFs with a practical tool that explains how can ADFs improve communication during the design process. The LTF provides a step-by-step framework to help ADFs integrate LT principles to overcome the causes of poor communication. This could be achieved through identifying communication problems, establishing objectives and selecting appropriate LT principles, developing LT integration plans, executing LT integration plans and monitoring and evaluating the integration plans. However, the LTF’s success depends on the encouragement of ADFs to facilitate the integration process. The application of the framework is a time-consuming process that requires full dedication from the project participants. The absence of senior management support hinders the implementation of the framework in ADFs in Egypt.

CONCLUSION AND RECOMMENDATIONS

The construction sector contributes significantly to the attainment of governments' social and economic development goals worldwide. However, it is plagued with complications and obstacles. People from various cultures, goals, and professions work together in various ways to achieve the overall aim of project success. Poor communication, especially throughout the design

process, is one of the most difficult aspects of a construction project. This is because decisions made during the design phase have an impact on the building's performance throughout its life cycle. Communication is a vital and dynamic activity that strives to provide an environment for information exchange and the transformation of customer demands and end-user requirements into engineering drawings and technical specifications. This might be accomplished by utilising a variety of communication methods such as vocal, nonverbal, written, visual, and computer-generated designs and documentation. Because of the rising expectations of clients and project stakeholders, the complexity of project design, advancements in building technology, and information management systems, communication has grown increasingly difficult during the design process. Accordingly, this research focused on investigating the role of LT in enhancing communication during the design Process. During this research, the literature review was used to investigate the nature of the design process, the causes and impacts of poor communication during the design process, and LT. Moreover, three case studies were collected and analysed to validate the identified causes and impacts of poor communication during the design process and to investigate the role of LT in enhancing communication during the design process. Furthermore, a survey questionnaire was conducted with a representative sample of ADFs in Egypt to investigate their perception and application of LT towards enhancing communication during the design process. Based on the above, the research developed an LT framework to improve communication during the design process. Accordingly, the research comes to the following recommendations:

1. Raising the awareness of ADFs towards the importance of adopting LT principles to overcome the causes and impacts of poor construction during the design process.
2. Enhancing communication between the client and design team through adopting the appropriate communication methods that help overcome the physical barriers and taking into account the impact of Covid-19.
3. Focusing on understanding the project value from the client's perspective, conducting proper identification of the project stakeholders and adopting the constructability concept towards simplifying the project design and facilitating the construction process.
4. Providing necessary training programmes, technologies, infrastructure and resources to enhance the skills of architects and stakeholders to enhance the project design and provide architects with adequate feedback, overcome the linguistic and cultural barriers as well as increase the architect's honesty and integrity.
5. Improving the workplace environment to reduce work stress ad pressure on the design team and organise the multi-organisational interaction during the design process.
6. Seeking Senior Management support to offer needed resources for using communication technologies, overcoming technology malfunctions, establishing clear communication channels and responsibilities as well as developing plans and procedures to enhance communication effectiveness and management.
7. Testing and validating the proposed framework to ensure its capability towards providing the benefits advocated above through surveying of opinions and stands of ADFs and government authorities.

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