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Using design thinking to enhance construction site problem solving

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Using Design Thinking to Enhance Construction Site Problem Solving

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DEDICATION

The Messenger of Allah (ﷺ) said, "When a man dies, his deeds come to an end except for three things: Sadaqah Jariyah (ceaseless charity); a knowledge which is beneficial, or a virtuous descendant who prays for him (for the deceased).”[Muslim].

I dedicate this work to my son Muhammed, whom I hope my humble work inspires him to greater efforts, may God accepts both my work and my son.

ACKNOWLEDGEMENTS

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I reserve a special acknowledgement to my family, specially my wife Amira, who supported me from day one to achieve this accomplishment. My father and mother, who raised me to love knowledge and always to aspire new achievements in my life, My two sisters Hala and Heba, as well as, my brother Waleed who always believed in me and my abilities and gave me unconditional support, my nephews who always look me up and made me want to be a better person.

Finally, I would like to thank my partners and colleagues at work for their support during my studies until the very last moment.

Abstract

Problem solving is one of the most important issues in Construction Management (CM), it influences the outcome of the project due to the amount of decisions and problems that the Construction Manager faces in each project.

Construction Management is a vital subject that has been in the spotlight of academic research for decades, which led to its emerging by going through the cycles of developing and evolution. The criteria of decision-making and problem solving have also evolved from focusing on the technical and objective aspects of construction to the soft and subjective ones. (Bakht, El Diraby 2015).

Nevertheless, the last two decades saw the rise of "Design Thinking" as a new approach for innovation and solving problems in a creative way, it is an approach calls for adapting more subjective, human and innovative problem solving.

Design Thinking was adapted in many aspects of social and business life with a great success (Lidtkaj 2014), however, no enough attention were given to it in the construction industry, which gives this research a special importance.

In this research, I am trying to examine the efficiency of adapting Design Thinking in solving problems in the construction sites, by means of conducting an experiment to examine whether Design Thinking will enhance problem solving or not.

Three simple problems were presented to multidisciplinary 21 participants, they were asked to solve these problems with their traditional (rule-of-thumb) method.

Subsequently, they were given a training session on Design Thinking, then they were asked to form small groups to work on the same problems again but this time by using what they have learnt in the Design Thinking session.

The experiment showed a great acceptance and understanding to this approach from the participants, over and above, the results have shown a significant enhancement in problem solutions resulted from Design Thinking session compared to traditional method one. The results are encouraging for more research on how we can adapt Design Thinking approach in construction industry, since it proved to have the potential in helping developing Construction Management.

Keywords: Problem solving; decision making; Design Thinking; Construction Management; Innovation.

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Chapter 1

The Introduction

Problem solving and decision-making have been an area for continues investigation and research for a long time, specially, in the construction management. The construction / project manager faces daily challenges in many activities that need immediate decisions on site, for example; the resources that should be managed, expected and unexpected problems that should be solved.

Project management (PM) always provide the tools and techniques to help the construction/project manager to deal with these challenges; for instant, planning techniques, resource management tools ….etc. Although, all these tools represent the platform of the project manager that relies on his duties, yet, it cannot replace the human ability in the problem solving. The decisions made by Construction/ Project manager affect the product of any project by default.

The continuous growth and rapid changes raise the question of how we can enhance the quality of problem solving and that brings a special importance to this research, which aimed to investigate the possibility of bringing innovation to Construction industry.

In this research we will see that the more the problem solutions are innovative the more its quality is increased, that brings us to study and understand what innovation is in the first place; Innovation was described as thinking out of the box. However, it is more accurate to describe it as achieving the Radical Breaks. According to Jonathan Edelman et al, Radical Break is reframing the problem to find a new and a unique solution to it. (J. Edelman 2012).

Design Thinking is considered one of the emerging approaches to achieve innovation, as appears from its name it adapts the methodology of design and designers to solve problem. It is also being referred to as the methods and processes of investigating challenges, acquiring information, analyzing knowledge as well as putting the solutions in the design and planning field.

As a style of thinking, Design Thinking is considered the ability to combine empathy, creativity, and rationality in analyzing and fitting solutions into context (Plattner 2012). For that reason Design Thinking is gaining a great attention in business globally these days.

Many companies are adapting it as a way to achieve innovation. However, it is not being used widely in the Construction Industry. There are hardly any efforts neither any attentions

paid to investigate the success of adapting the Design Thinking in Construction Management. Therefore, the main aim of this research is to shed the light on the importance of using Design Thinking in construction management and to be one of the few efforts that highlight its importance.

1.1 Problem Solving in Construction Management

Decision making and problem solving are heavily investigated, the researchers and scholars have intensive efforts trying to frame this subject since it affects every aspect of life; business people, policy makers, economists, engineers, and doctors ....etc.
Making decisions everyday influence these people's work, the community around them and sometimes it affects a scope wider than their society.

In Construction Management, problem solving represents the key behind project success and companies growth. The quality of decisions made by management team is vital; it manipulates the financial, environmental as well as the social aspects of any project.

Today's decision making in construction engineering and management (CEM) is characterized by a strong influence on social and business aspects that is parallel or even surpass the traditional technical consideration (Bakht, El-Diraby 2015). Yet, it could not beat these traditional considerations unless it passed through decades of evolution and development affected by surroundings growth of knowledge and information technology. Table (1) shows the change and evolution of trends in decision making in construction engineering and management (CEM) from the 1960`s till 2000`s based on the work and research of Mazdak Nik Bakht and Tamer E. El-Diraby (Bakht, El-Diraby 2015).

TABLE (1) EVOLUTION OF PROBLEM SOLVING AND DECISION MAKING IN CONSTRUCTION.

1960s	Baby Steps from Statistics toward Stochastic Approach.
1970s	Softer And Non Technical Criteria.
1980s	Operation Research; AL, And Organizational Decision Making.
1990s	Integration And Automation of Systems and Processes.
2000s	Integration of Decision Makers.
Future	Construction-Related Decisions Must Be Made By a Network Of Decision Makers Rather Than an Individual or Hierarchy.

1.2 Twenty First Century Skills

As mentioned earlier, Nowadays challenges have impact in different directions of life; environmental, social or financial, therefore, it requires a different type of skills to be able to deal with those challenges and problems. Some researchers developed the concept of the twenty-century skills (Pink 2006; Wagner 2010; Gardner 2006).

Tony Wagner calls those skills (The seven survival skills for careers, college and citizenship). (Wagner 2011):

- Critical thinking and problem solving.
- Collaboration across network and leading by influence.
- Agility and adaptability.
- Initiative and entrepreneurialism.
- Effective oral and written communications.
- Accessing and analyzing information.
- Curiosity and imagination.

While Daniel Pink highlights in his book 'A Whole New Mind' (Noweski et al 2012) some essential aptitudes on which professional success and personal fulfillment nowadays depend (Pink 2006).

- Design : to detect the pattern and opportunity.
- Story : to create a narrative artistic and emotional beauty for a satisfying craft.
- Synthesis : to combine seemingly unrelated ideas into a new something.
- Empathy : the ability to empathize with others and to understand the subtleties of human interaction.
- Meaning: to find joy in a self and to elicit it in the others and to stretch beyond the quotidian in the pursuit of purpose and meaning.

Finally, Harvard professor Howard Gardner describes those skills in his book 'Five Minds for the Future' as:

- The Disciplinary Mind: the pastry of the major schools of thought, including science, mathematics and history, and of at least one professional craft.

- The Synthesizing Mind: the ability to integrate the ideas from different disciplines or spheres into a whole coherent and communicate that integration to the others.
- The Creating Mind: the capacity to uncover and clarify new problems, questions, and phenomena.
- The Respectful Mind: awareness of and appreciation for differences among human beings and human groups.
- The Ethical Mind: fulfillment of one`s responsibilities as a worker and as a citizen.

Those skills, as will come later, are of a great importance as they integrate with the Design Thinking tools to facilitate solving problems, detecting patterns, synthesizing ideas and creating solutions.

1.3 Design Thinking

Design is an old human activity; it goes back to the time when man needed to build his home, temple or even his first tool or machine. Design has evolved through history into a systematic activity, different design schools were built for either architecture or industrial design. In many ways Design is a way for solving problems, which is in those cases were the design assignment. Hence, in the recent years, this systematic approach has been adapted in the domain of business management to serve a broader spectrum than architectural or product design.

Design Thinking goes back to Thomas Edison's days; Tim Brown claims that this scientist used an early example of Design Thinking methodology where he used the full spectrum of innovation activities and imposed it with human-centered design ethos (Brown 2008).

However, it is the recent decade or more that witnessed the evolution of Design Thinking into a field of study for business innovation, which is described in many ways as the obverse of Scientific Thinking (Owen 2006).

Design Thinking has many definitions; it is described as; a complex thinking process of conceiving new realities, as well as expressing the introduction of design culture and it's method to fields such as business innovation (Tschimmel 2012). Design Thinking is also explained as an application that provides business with the tools to find the breakthrough in innovation as well as a robust scaffold for different problem solving. It also engenders a

sense of creative confidence that is both flexible and highly optimistic (Goldman et al 2012), hence, there is a widespread adaption of the Design Thinking around the world recently.

1.3.1 Design Thinking In Real Life Applications

Some researchers were interested in studying some success stories of Design Thinking, the following are some examples of adapting Design Thinking in Business and social innovations.

1. ***Deloitte Australia***, The financial service company introduced thinking organization to practice Design Thinking, it was an opportunity to create better outcomes for the people they serve for both the internal and the external stakeholders (Howard 2012)

2. ***SAP***, the German-owned business process management company, melded the design thinking with the traditional approaches with strategy in order to compose and communicate new strategies around the nebulous concept of Web 2.0. (Liedtka 2011)

3. ***Toyota***, employed Design Thinking to analyze one of its West Coast customer-contact centers from the ground up, engaging a cross-functional team of frontline call reps, software engineers, business leaders and change agents in a redesign process that transformed the service centre experience for both customers and associates. (Liedtka 2011)

1.3.2 The Design Thinking Model.

Design Thinking process is a cyclic process rather than a linear one, in which the designer can move between different phases until he finds the break through. There are more than one approach for Design Thinking process, a lot of effort has been invested in developing these processes, However, the common factors of all these approaches depend on the concept of ¨building ¨ solutions rather that ¨finding ¨ solutions, and this can be considered as one of the major characteristics of Design Thinking.

TABLE (2) DIFFERENT MODELS OF DESIGN THINKING.

	Process	Developer/ Creator
1	3I`s (Inspiration, Ideation, Implementation)	Tim Brown, IDEO
2	Human Centre Design	IDEO
3	Hasso-Platner Model (Understand,Observe, Point of View, Ideate, Prototype, Test)	Hasso-Platner Institute of Design
4	The 4D or Double Diamond (Discover, Define, Develop, Deliver)	The British Council
5	Service design Thinking (SDT)	Stickdorn & Sheider
6	The 4 question Model (What is, What if, What wows, What works)	Liedtkaj, King & Bennett

1.3.3 Design Thinking Tools.

Design Thinking has different methods and approaches as well as a variety of tools. However, Design Thinking as a concept encourages the innovation and creativity in a greater way. Therefore, in the process of solving a problem a person may create a new tool or use an old one in a different way, as long as it gives a good input in each phase of the different Design Thinking phases.

In this research, we chose some tools that the participants are relatively familiar with, in order to help them implement Design Thinking easily in the experiment.

Those tools were as follows:

- Activity Time Chart.
- Backcasting.
- Brain Storming.
- Empathy Map.
- Goal Grid.
- Mind Mapping.

- Mockups.
- Scenarios.
- Sowt Analysis.

1.4 What is the importance of this research?

As stated earlier, problem solving is vital in the Construction industry, it has been in the spotlight of research for a long time, and will continue to be. Meanwhile, the last two decades have witnessed the rise of Design Thinking approach as a new paradigm shift in; innovation, decision making and problem solving, however, no great attention was paid to relate both domains, Construction Management and Design Thinking.

Currently, many businesses adapted Design Thinking as their springboard for creativity, hence, the time is due to test the effect of Design Thinking on problem solving in Construction Management, and that brings a special importance to this research.

In our study we tried examining the effect of Design Thinking on problem solving in the construction sites, thus open the door for more investigation on this subject that may support the work done in the field of Project Management as well as in the Construction industry in general.

1.5 The Overall Objective of The Research.

The objective of this research is to assess the impact of adapting design-thinking method on the problem solving process on construction site by answering the following questions:

- Does using design thinking enhance the problem solving process on construction sites? To answer this question, we need to analyze solutions produced by the design thinking process and we need to have a reference to determine the amount of enhancement if there is.
- Will the construction team be more creative and innovative using such tools? This question needs a different type of analysis to determine the innovation of the solution.
- Finally, if there is any enhancement to the solutions, do all problems have the same level of improvement, and whether or not those problems affect the outcome? To answer this question we will need to compare different problems with various types and analyze their solutions.

By answering those questions, we will be able to evaluate the impact of design thinking on construction problem solving and the possibility to develop this usage on a wider range in the construction industry. Moreover, we will be able to know the respond of the construction team to this relatively new method of thinking and how we can benefit from its impact.

Chapter 2

Literature Review

2.1 INTRODUCTION.

Decision-making and problem solving are common areas of interest for human kind in social life as well as business; therefore, it occupied a great area in the academic and non-academic literature. Scientists, researchers, and scholars have investigated the processes of making decisions and solving problems, as well as enhancing their abilities.

In his book 'Thinking fast and slow' Daniel Kahneman - a recipient of the Nobel Prize- explains the two systems of decision making; system (1); the fast, intuitive and emotional and system (2); the slow, more deliberative and more logical (Kahneman 2011).

While in their book 'Judgment in Managerial Decision Making', Bozeman and Moore introduced a number of cognitive biases that are likely to affect the judgment of all types of professionals, more over they suggest some strategies to overcome them to become a better decision maker (Bazerman, Moore 2009).

Construction Management is a major topic as well; therefore, it occupied the attention of many researchers. However, the link between the decision-making and problem solving in the construction field is still very weak; thus, this chapter tries to shed some light on the efforts made in both domains - Construction Management and Design Thinking- and the efforts done to link them both together.

2.2 Problem Solving and Decision Making in Construction Management.

The success of any construction project depends greatly on the effectiveness of the problem solving process exercised by site managers (Charoenngam, Maqsood 2001). Casper S. Schultz examines this claim in his research, as he addresses the quality issues that are related to the project management, he examines the role of problem solving practices in the creation and positive re-addressing of the failures and defects in construction processes (Schultz 2012). Therefore, he advises the companies to direct their attention not only to planning processes, but also to facilitate and support the problem solving tools and improve the skills of the project managers.

Moreover, Construction Management (CM) has witnessed evolution starting mid of the past century, and development of recent trends such as, sustainability, increased desire for public engagement and globalization in construction. These trends have influenced the

environment under which decision makers work, argues Mazdak Bakht and Tamr El-Diraby. Therefore, they reviewed the literature research concerning this subject to provide a perspective on the evolution of decision making models and tools in the construction field, through analyzing a representative set of papers published in the J*ournal of Construction and Management (J. Constr. Eng. M) over the last* 50 years(Bakht, El-Diraby 2015).

Mazdak Bakht and Tamr El-Diraby have detected a shift from an assumption of individual decision makers to a hierarchical structure, and more recently, to a network of decision makers. They also found that decision criteria have evolved from focusing on the technical and objective aspect to the soft and subjective aspect of construction, which have promoted the application of emergent-based selection methods, particularly in infrastructure projects.

This claim echos what Maqsood et al previously stated, that projects are increasingly becoming highly competitive, more complex, and difficult to manage. They added that Projects in general became 'wicked problems', which are difficult to solve using traditional approaches. They defined Soft Systems Methodology (SSM) as a system approach that is used for analyzing and solving problems in complex and messy situations (Maqsood et al 2003).

Maqsood et al also have examined the benefits of applying SSM to wicked problems in construction project management; especially those situations that are hard to be understood and difficult to act up on. These situations need to adapt Soft Systems and Soft Skills to help in problem solving.

In addition, it is important to state the findings of Christine Noweski et al; in their claim, they stated that science, business and social organizations, equally determine a strong need for a set of skills and competences, that were often referred to as the twenty-first century skills and competences (Noweski et al 2012). Noweski et al also highlight the need to have these skills and competencies in the education practice, moreover, they point to some initiatives such as; the Partnership for twenty-first century skills and the Cisco/Intel/Microsoft assessment as well as the teaching of the twenty-first century skills project.

2.3 Design Thinking

In the last few years, Design Thinking has gained popularity, it is now seen as an exciting new paradigm for dealing with problems in different sectors such as; Business, Education and Medicine. Most fields that are eager to adopt Design Thinking approaches seem to focus their interests on the creative and generative elements of the design professions; after all, this is what design is commonly known for (Kees, Tietz, 2011).

The question that immediately rises when hearing the Term Design Thinking will always be what is the relationship between design and problem solving? Tim Brown and Barry Katz argue that over a century of professional practice, designers have mastered a set of skills that can be productively applied to a wider range of problems than has commonly been supposed, these include; complex social problems, issues of organizational management, and strategic innovation. Conversely, non-designers who are in leadership positions in companies, governmental and non-governmental organizations, as well as professionals in a broad range of services and industries can benefit from learning how to think as designers (Brown, Katz 2011).

Charles Owen believes that while Design Thinking is less known than scientific thinking, it is distinguished by having a great value to teams that are dealing with complex, ill-formed problems. Together, the characteristics of design thinking and the scientific thinking form a set of complementary thought process, which are able to add considerable strength to advisory task (Owen 2006).

Design Thinking has many explanations; all the definitions frame it as an approach for innovation in problem solving. It can be defined as a specific method to solve complex (wicked) problems and to generate innovative solutions based on a user-centered approach with multi-disciplinary teams.

Design thinking, which is introduced and shaped by the design consultancy IDEO, is becoming more and more popular among business schools, and is applied in R&D departments of companies to foster innovation (Katja, Muller 2011).

The Hasso-Plattner-Institute of Design at Stanford University in California, USA together, with The Hasso-Plattner-Institute of Design (HPI) for IT System Engineering in Potsdam, Germany, agreed on the same definition of Design Thinking. Both define it as, the

methods and process for investigating challenges, acquiring information and analyzing knowledge as well as positioning solutions in the design fields, furthermore they defined the planning fields as a style of thinking.

In general, Design Thinking is consider being the ability to combine empathy, creativity, and rationality in analyzing and fitting solutions to context (Hasso Plattner 2012). In another definition, Reem Razzouk and Valerie Shute identify it as an analytic and creative process that engages a person in opportunities to, experiment, create and prototype models, gather feedback, as well as redesign (Razzouk, Shute 2012).

Many researchers have investigated the success of Design Thinking in the business field, especially in the non-design activity, in order to give an assessment about how successful it is. In her study, Jeanne Liedtka claimed that Design Thinking was in fact a problem solving process, not just an innovation process. In her research, she has viewed 10 successful stories of either organization that adapted Design Thinking on the scale of a project or on the whole organization. Companies like Suncorp, SAP, Toyota and IBM are amongst the organizations in her study, each one of them has its own application. (Liedtka 2011). While, Zanna Howard reviewed the experience of Deloitte Australia; the financial services firm, in adapting Design Thinking within the organization's practice (Howard 2012).

There were some applications in other social and wellbeing organizations; as in the case studied by Dorst, K. and C Tietz, in which the organization applied a practical way to supply health-hardware that contributes towards the physical wellbeing, also, it helped improve and sustain health for the whole community, in this case, indigenous communities in Australia (Dorst, Tietz 2011).

In another research, Noweski et al cited the methodology of John Dewey, who proposed recommendations for constructivist problem solving which was later transformed into the project-method by his student William Heard Kilpatrick in 1918. Dewey`s approach was related to the natural science, the approach started with an inquiry unfolding a problem or a difficulty, which was in that time a motivation for further analyses and exploration. New insights, the researchers claim, are the basis for an explanation of that inquiry, and is followed by a plan of action to solve the problem. Dewey recommended the following aspects:

- Problem situated in a real-life context.
- Interaction of thinking and action.
- Interaction and sharing knowledge between the learner and the teacher.
- Problem-solving and interpretation of insights.
- Reflecting and understanding through application of ideas.

In conclusion, Dewey`s perspective on learning and education entered a real-life inquiry, in which it has to be analyzed as a whole complex (deductive). Dewey also compared his recommendations and his adaption in the project-method with the design thinking method (Noweski et al 2012).

2.4 The Research`s Experiment

With all the academic efforts that were made to investigate the applications of Design Thinking and problem solving in business, few literatures focused on Construction Management. Consequently, a study of a collection of these few researches dealing with decision making in Construction Management as well as experiments in Design Thinking had to be prepared, in order to build our trial on academic knowledge, and hence tailor an experiment that suits the objective of this research.

2.4.1 Data collection

Charongamm and Maqsood conducted an experiment, in which Ninety-nine civil engineers were presented with common familiarity on-site problems, through both various informal intuitive and formal non-intuitive tools and techniques. The nature of tools employed found to have an effect on problem recognition (Charongamm, Maqsood 2001).

On the other hand, Chang et al have depended on history data to study the patterns of decision making in Construction; they used a text mining method that expedites the identification of construction problem-solving patterns, from the 908 historical LLFs, that was recorded in the KMS of the case engineering consulting firm (Chang et al 2012).

Jonathan Edelman et al research about understanding the radical breaks, observed the response of small teams by video recording. Non-hierarchical 14 teams were engaged in a 30 minutes redesign task (J. Edelman et al 2012). In another experiment to assess the understanding of school students, 4 classes of 116 student were split into teams of 4 and 5 students, then they had to work on a 3 day challenge (C. Noweski et al 2012). Working in teams seems to be a common action in those experiments, whether in construction problem solving or understanding Design Thinking.

2.4.2 Experiment Objective

Each of the studied experiments had objectives, tools and procedures to assess the impact of Design Thinking on a team or on the working environment. These objectives had similarities with this research objective as well. Therefore, we will review the objectives of each experiment in order to determine their impact on construction field and to see if we can use them as a guide in future projects.

The main objective of Charongamm and Maqsood is to explore the problem solving processes of the site managers thorough the use of various tools and techniques and examine the influence of various natures and level of civil engineering experiences. In general, there is a need to explore the problem solving processes to see various attributes or factors that may render this process ineffective. Moreover, to confirme whether the nature of the management tools or techniques employed who assist the problem solving process produces an effect on this process or not (Charongamm, Maqsood 2001).

Maqsood continued his efforts on the same subject; he tried to investigate the use of Soft System Methodology (SSM) in solving wicked and ill-defined problems, which is similar to the usage of Design Thinking in Problem solving. Maqsood et al claims that the Soft Systems Methodology (SSM) is a systems approach that can be used in analysis and problem solving in such complex and messy situations. SSM uses “systems thinking” in a cycle of action research, learning systems and reflecting them are the process of helping understand the various perceptions that exist in the minds of different people who involved in the situation (Maqsood et al 2003).

The Soft System Methodology (SSM) has similarities with Design Thinking in its approach and process as it requires the same type of the twenty-first century skills.

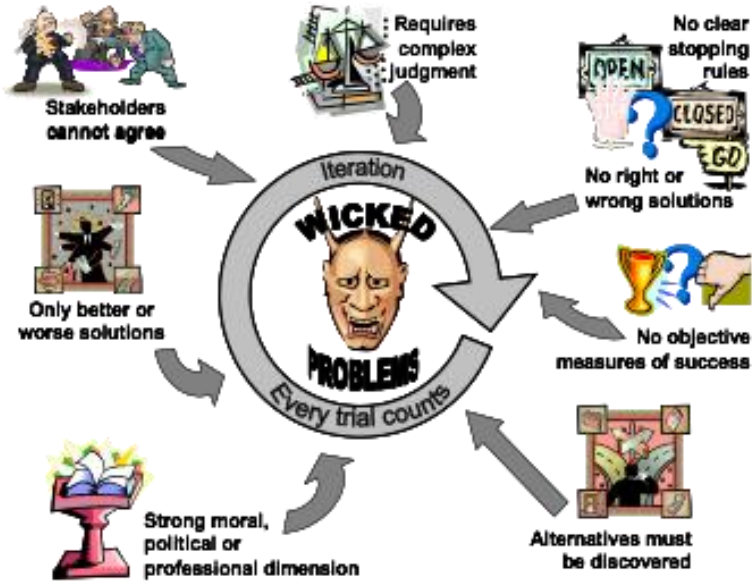


FIGURE (1) THE NATURE OF WICKED PROBLEMS (MAQSOOD ET AL 2003)

2.4.3 Design Thinking Models.

The process of Design Thinking had its share of experiments as well as of research investigations. In a critical analysis of Design Thinking, Rodgers and Winton found that Design Thinking is thought to be a system of three overlapping spaces rather than a sequence of orderly steps. Those three spaces are *Inspiration*; which is the problem or opportunity that motivates the search for solutions. *Ideation; which is* the process of generating, developing and testing ideas and finally the *implementation;* which is testing and implementing the best ideas generated, besides, the path that leads from the design studio, lab and factory to the market.

In their paper, Rodgers and Winton seek to examine and analyze critically the tenets of this new design thinking process as a manifesto set against three case studies of modern design practice. As such, they compared Design Thinking theory with the reality of design in practice (Rodgers and Winton 2010).

TABLE (2) DIFFERENT MODELS OF DESIGN THINKING.

	Process	Developer/ Creator
1	3I`s (Inspiration, Ideation, Implementation)	Tim Brown, IDEO
2	Human Centre Design	IDEO
3	Hasso-Platner Model (Understand,Observe, Point of View, Ideate, Prototype, Test)	Hasso-Platner Institute of Design
4	The 4D or Double Diamond (Discover, Define, Develop, Deliver)	The British Council
5	Service design Thinking (SDT)	Stickdorn & Sheider
6	The 4 question Model (What is, What if, What wows, What works)	Liedtkaj, King & Bennett

In the coming pages we will study briefly, the different models of design thinking.

1) **The 3I process**

The three overlapping processes called the (3Is), which were found by Tim Brown of IDEO, are widely used and adapted, (Brown 2008). He named these processes the (3Is) as it depends on three phases:

*Inspiratio*n: In the first phase, the designer uses Design Thinking tools to understand the problem, frame it, and look for potentials and opportunities.

Ideation: In the second phase, the team starts brainstorming to generate ideas and build a creative framework, by focusing on the human aspect, and using storytelling tools and quick prototyping.

Implementation: This is the third and last phase, where the designer tries to take his idea to reality, by testing its possibilities, and fails early to see flaws before putting it in full practice. (Brown 2010). This process was developed by IDEO; an international design firm; in 2001 (Tschimmel 2012).

In our research, we depended mainly on applying the (3Is) processes, since it was the most appealing for the participants.

FIGURE (2) THE 3IS DESIGN THINKING MODEL (TSCHIMMEL 2012).

2) IDEO`s HCD Model

The IDEO`s HCD Model refers to Human Centered Design, a major character of Design Thinking. This model puts human needs and requirements in the center of the design process (IDEO 2015), It was develop by IDEO in response to Bill & Melinda Foundation call for a process for NGO and social enterprises (Tschimmel 2012).

FIGURE (3) HUMAN CENTRED DESIGN THINKING MODEL (TSCHIMMEL 2012)

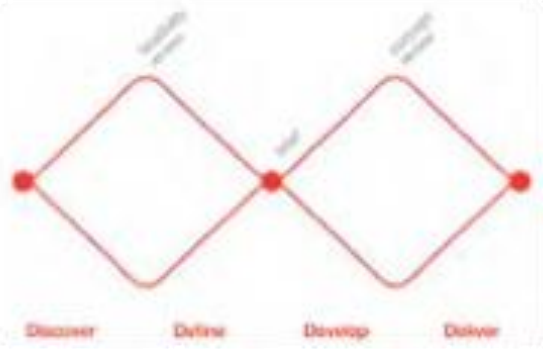


FIGURE (4) THE 4 D OR DOUBLE DIAMOND MODEL (TSCHIMMEL 2012).

3) The Model of the Hasso-Plattner Institute

This model developed by the Hasso-Plattner institute of design and consists of six steps; Understand, Observe, Synthesis, Ideate, Prototype and Test (Noweski et al 2012)

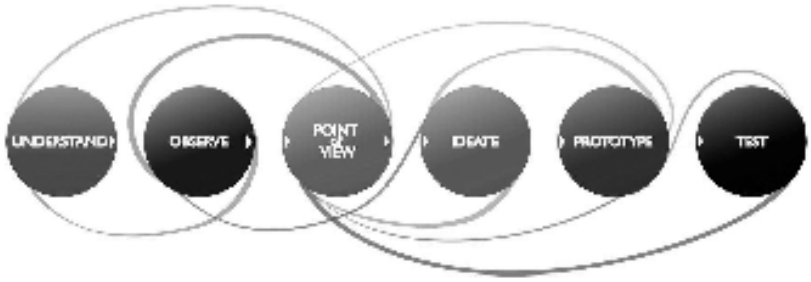


FIGURE (5) HASSO PLATNER DESIGN THINKING MODEL (THORING & MÙLLER 2011)

4) The 4D or Double Diamond Model of the British Council.

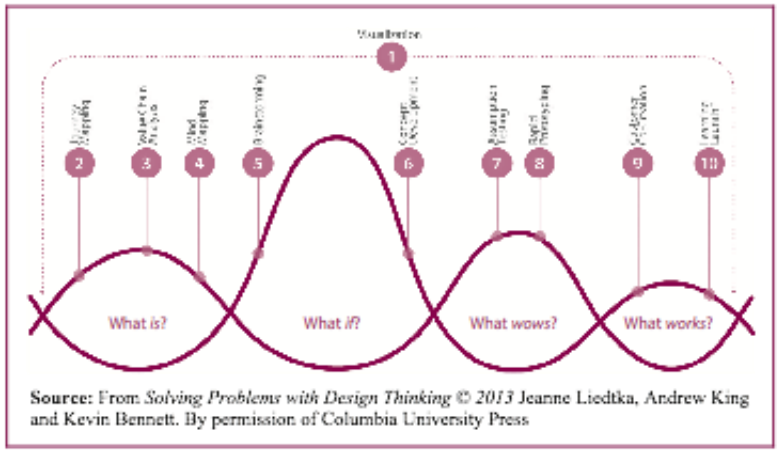
This process was developed by the British Council in 2005 and consists of 4D phases, which are, Discover, Define, Develop and Deliver (Tschimmel 2012).

5) The Service Design Thinking (SDT) Model

Another process, published by Stickdorn and Shneider in 2010, called the Service Design Thinking Model. It was composed of 4 phases; Exploration, Creation, Reflection, Implementation (Tschimmel 2012).

6) The four questions Model

This model depends on asking four questions that lead to solve problems by Design Thinking; these questions are, What is? What if? What wows? and What works? (Liedtka 2011)



Source: From *Solving Problems with Design Thinking* © *2013* Jeanne Liedtka, Andrew King and Kevin Bennett. By permission of Columbia University Press

FIGURE (6) THE 4 QUESTIONS MODEL (LIEDTKA 2011)

2.4.4 Assessment And Evaluation

Different techniques were used in the experiment's assessment and evaluation in the literature reviewed. In their researches, Charongamm and Maqsood used a web-based questionnaire, referred to as "the virtual site", in this questionnaire a graphically illustrate site information captured by various techniques, followed by analyzing the data they chose "Content analysis". In their research, various participants have answered the open-ended questions in a variety of ways, and hence it gave a clear interpretation of their intentions as well as their opinions, it also provides an insight into their thinking processes (Charongamm, Maqsood 2001). We found that the web based questionnaire process is the most appropriate approach for analyzing the type of data gathered in that research.

In another research, Chang et al have applied the text-mining methods to identify the keywords of the technical domain. The commercial data mining software adopted Microsoft SQL Server® to find out the meaningful patterns. Finally, it identified 13 patterns verified by the domain experts who participated in solving the referred engineering problems (Chang et al 2012).

In order to study the role of problem solving in construction management practice, Casper S. Schultz carried out a 15-month ethnographic field study comprised of workplace observations and qualitative interviews. It helped him study the internal structures of the agents, the effect of their general-dispositions regarding quality issues in the decision-making, as well as the re-addressing of defects and failures in the processes. (Schultz 2012) After conducting the semi-structured interviews, participant observation, and artifact analysis, to collect data from June to September 2011 at the Melbourne Deloitte office, Zana Howard conducted ethnographic methods to assess the findings of Deloitte's approach to build awareness and a consistent understanding of design thinking (Howard 2012). She conducted a research to assess how innovative Design Thinking is if compared to a non-Design-Thinking approach.

Noweski and Meinel held an experiment between 20 Design Thinking trained students versus another 20 non-Design -Thinking trained, In fact, they wanted to compare inter-disciplinary teams against the mono-disciplinary ones. The outcome of the experiment was given grades by experts and then evaluated by participants themselves, this rating system was used to confirm the hypothesis of the research that trained multidisciplinary Design Thinking teams who were more innovative than non-trained mono-disciplinary ones (Noweski, Meinel 2010).

In a five-step, Design thinking process in the educational museum game design, Gestwicki and McNely relied ethnographic data collected during the experiment from multidisciplinary teams of participants, to describe five steps of the design thinking process. This data was collected through field notes, analytic memos, audio recordings, interviews, photographs, videos and artifacts that were collected from participants after the experiment. (Gstwicki, Mcnely, 2012)

2.5 Conclusion

Researches and papers reviewed in this chapter had a great importance on this research; they represented the platform that the experiment was built on. In the construction field, there was effort made to investigate problem solving in Construction Management, Its evolution through years and what skills we need to face the recent and future challenges. The literature reviewed also shed the light on the definition on Design Thinking and its process and tools.

This quick review of Design Thinking was important in drawing the picture of this research, as it is still a new concept -The Design Thinking-. Therefore, it was important to give a comprehensive introduction about it.

The final part of the literature review was about the experiments and the studies made trying to find similar efforts to help in designing this research experiment. However, as stated earlier, there was no research that connected Construction Management with Design Thinking except one research (Eduardo et al2013) in Portuguese which gave a general review about Design Thinking, however, there was no experiment to examine both domains together.

Some experiments investigated problem solving in Construction and it was important to review their research objectives, data collection techniques and data analysis. It was also very important to review Design Thinking experiments, to study its data collection and analysis techniques.

In conclusion, although the literature was not reviewed by big number of researches, due to the novelty of the topic, yet it was very important and fundamental to study and evaluate them in order to design this research's experiment.

Chapter 3

The Experiment Design

3.1 Introduction

To answer the questions behind this research, an experiment was designed to compare two types of solutions for a certain problem. First solution generated from participants with traditional mode of thinking; depending on their intuition as individuals, we will consider these solutions *Traditional Thinking solutions*. The second solution generated by the same participants but by adapting the *Design Thinking* methodology.

The items of the experiment are:

- **The participants.**
- **The venue.**
- **The problems.**
- **Design Thinking crash course.**
- **Sessions scenario.**
- **Data collection & extraction.**
- **The analysis.**

3.2 The Participant

This experiment requires multi-disciplinary group of participants with diverse experiences and backgrounds, the experiment will be held on multiple sessions. Therefore, it will be more efficient if all participants were chosen from the same company for the following reasons; First, It was important to have a homogeneous group with a common culture, if the group was composed from different companies, that would add another influence while comparing problem-solving techniques. Second, to give flexibility in sessions timing, it would be easier to arrange with company's management all sessions which would be very hard to arrange with different companies, as It won't be easy for participants to agree on suitable dates.at first, they will work individually, and later on they will work in teams afterwards. Therefore, the number needs to be not less than 20 participants in order to have 8-10 teams; each team should have from 2-3 persons.

3.3 The Venue

To hold this experiment, it required a venue that can host different sessions and fulfil the following requirements:

- Proximity to participants, in order not to suffer while attending the consecutive sessions.
- Equipped with all presentation facilities.
- Comfortable for teamwork, so that participant would find it easy to work without obstacles.

3.4 The Problems

Choosing the problems of the research was one of the most critical tasks, since, the problems have to be diverse, with different natures to test the ability of the participants, if we deal with similar problems, it will not be easy to evaluate the impact of Design Thinking on the output accurately. In order to do that, there were some criteria to put into consideration while electing;

- The problems have to be diverse in the nature of addressing the different aspects that face the construction manager; like materials, personnel or planning.
- Problem solution has to be within the authority of the construction manager, so, the participants will feel that they have an input to add.
- Problems should be familiar to participants; they should have experienced similar problems, whether by success or fail.

After assessing many types of problems, three problems were chosen; these problems were identified as the most suitable for the experiment.

- Problem (A) addresses the time of planning in the holy month of Ramadan.
- Problem (B) addresses the introduction of Health & Safety measures in a construction that lacks it.
- Problem (C) addressing the controlling of the waste in building materials, particularly, in brick works.

A brief was prepared for each problem to be introduced in the experiment sessions; the same brief was presented to the participants twice, once using the Traditional Thinking and the other using Design Thinking method.

3.4.1 Problem's Brief

Problem (A): The holy month of Ramadan represents a massive challenge in the construction industry, the change in daily routines and activities tend to have conflict with project's schedule, as productivity tends to drop significantly. As a site manager, you have to work with the planning team and the construction team on this issue, to avoid a huge drop in productivity, which might affect the delivery date of the project, and might cost your company more expenses.

The solution for problem (A) is to find a way to prevent a huge drop in productivity of the construction team. This solution should be within the authorities of the site manager to be applied successfully.

Problem (B): As your company gets bigger and targets more projects, it starts applying important new systems that were not aware of before. The Health and Safety measures are considered one of these systems, while the company starts to invest in health and safety, you were asked to introduce it to your construction team, and to apply it correctly. In addition, the company gets the benefit of this system and avoids any wrongdoing. There will be a health and safety officer to apply this system. However, your role is to help him communicate with the construction team and to make this introduction successful.

Problem (C): As a site engineer/ manager you deal with different kinds of resources, building materials represent important resource and managing it correctly will definitely lead to project success. For example, the brick is one of the important materials in the construction site and it is very difficult to handle, as it is required in massive numbers, which leads to notable percentage of waste. As a site engineer/ manager if you can find a solution to reduce the amount of waste in brick works, it will reflect on the financial success of the project.

The solution of this problem should be within your authorities as a site engineer/manager and it should be easily to apply and to progress.

Each participant was asked to work on the 3 problem individually in session (1), and then they assembled groups of 2-3 persons to work on the same three problems again in the rest of the sessions.

3.5 Design Thinking Crash Course.

As none of the participants had technical knowledge of the process of Design Thinking, training has to be prepared for them. This training has to be concise and simple in a way that leads the participants to apply directly the skills they have learnt. The Design school at Stanford University, California, has introduced a crash course for Design Thinking; this course application is available on this link (http://dschool.stanford.edu/dgift/).

The training in this research was designed based on that Stanford crash course. It was about introducing Design Thinking through a systematic process while applying the skills that they have learnt directly in each phase. That crash course was designed to take 90 minutes, during this time, they were given a small project to work on. The attendees were split into groups of twos to perform a Design Thinking experience to solve a particular problem; in that case, the problem was how to design a new gift for a friend.

To tailor crash course to fit the purpose of our research; the assignment was changed. Therefore, the participants have to solve research problems while learning the Design Thinking process. A simple handout was designed as well to show the participants samples of the tools that they can use in each phase.

The steps of the course are as follows:

3.5.1 Introduction.

The introduction is to give the participants an overview about the concept of Design Thinking and the different approaches of thinking and problem solving.

3.5.2 Motivational Activity.

The original course starts with what psychologists call Ice Breaking, through which the participants engage in a quick activity to warm up and enable them to remove any psychological barriers. In our research, the *Ice Breaker* was replaced by a motivational video to show participants how innovation can be created through Design Thinking. An 8 minutes video to show a workshop on a design assignment for the IDEO team to redesign a shopping cart. The purpose of this video is to refresh participant's minds and to inspire them to achieve a similar break through.

3.5.3 Phase 1 (Inspiration) 25 minutes

The purpose of this phase is; to frame the problem, find an opportunity, observe what people think, then study their need (Brown, 2008).

In the beginning, Participants have to define the problem. Problem definition comes through collection of tools, brain storming, empathy, visual research or any other tool to enable the team to have an accurate definition of the problem. At the end of this session, the team should come up with a full picture about the assignment they are facing.

3.5.4 Phase 2 (Ideation) 25 minutes

In this phase, based on the problem framing from phase (1), participants have to sit together to generate as much ideas as possible, Even if some are not applicable, the flow of the ideas will help the team see the problem from different angles in order to achieve a break through.

3.5.5 Phase 3 (Implementation) 25 minutes

From the generated ideas in the previous phase, the team should come up with a solution that addresses the problem from different angles; they should discuss this solution and test it to see the feasibility of its implementation.

3.6 Research Data collection.

The output of this experiment is a collection of data that will lead to answer the main question of this research. Therefore, it needs to be recorded carefully and precisely, next, information needs to be extracted from the data collected, last of all, the stage of data analysis that will give the final answer to the main questions.

3.6.1 Data Recording.

There will be different types of data in this experiment:

1. Participant's interaction; which will be recorded by taking notes, photography and video recording, since, any note worth observing should be recorded to be recalled during data analysis phase.

2. Problems solutions by the participants will be handed out at the end of each session and this will be a pivotal type of information to assess solutions enhancement.
3. Participant's feedback will be collected to answer a questioner after finishing all sessions. This questioner will enable data collection about the participants, including data about their evaluation of the process and what kind of impact Design Thinking has on problem solving.

3.6.2 Data extraction.

The previously collected data represents the source of information of the experiment, however, before analyzing this data, it has to be extracted and transformed from its raw nature to a more organized shape. In order to do that, patterns are noticed, comparisons are applied and clear results are produced. The data should be sorted in unified tables, in the same number and order of each session. So, it would be easily compared, especially that the participants will be involved in the solutions evaluation. Each problem's solution should be organized in a table, more and above, the tools used in each session, as well as the keywords participants used while they are solving each problem have to be compared.

3.6.3 Data analysis and evaluation

The data extracted from the experiment can give us a clear picture about the questions of this research, however, it needs to be analyzed to detect patterns and make evaluations.

There are 3 areas that need to be investigated; the process, the problem and participants involvement and interaction.

1. The process.

The engagement with the process of Design Thinking applied during the experiment has to be evaluated on different levels of the three phases of Design Thinking (Inspiration, Ideation, and Implementation) along with how much the participants matched the characteristics of Design Thinking.

To perform the analysis and evaluation of the process according to the criteria mentioned above, rubrics have to be developed;

The first rubric will evaluate the quality of each phase of Design Thinking that the participants went through, the characteristic of each phase should have three levels of skill,

which will give an indication about the participant's engagement with each phase, were they excelled or would they need further training. Table (5) shows the template of the 3 phases of evaluation.

The second rubric will evaluate the characteristics of the outcome of each sessions submitted by the participants, this rubric was designed based on the characteristics of the Design Thinker by Charles Owen (Owen 2006) which was developed by Rim Razzuk (Razzuk 2012)

TABLE (3) DESIGN-THINKER CHARACTERISTICS (RAZZUK 2012)

Design-thinker characteristics

Characteristics	Description
Human- and environment-centered concern	Designers must continually consider how what is being created will respond to human needs. They should also consider environmental interests at a level with human interests as primary constraints for the design process.
Ability to visualize	Designers work visually (i.e., depiction of ideas).
Predisposition toward multifunctionality	Designers should look at different/multiple solutions to a problem and keep the big picture of the problem in mind while focusing on its specifics.
Systemic vision	Designers should treat problems as system problems with opportunities for systemic solutions involving different procedures and concepts to create a holistic solution.
Ability to use language as a tool	Designers should be able to verbally explain their creative process forcing invention where detail is lacking and expressing relationships not obvious visually (i.e., explanation should go hand in hand with the creative process).
Affinity for teamwork	Designers need to develop interpersonal skills that allow them to communicate across disciplines and work with other people.
Avoiding the necessity of choice	Designers search competing alternatives before moving to choice making or decision making. They try to find ways to come up with new configurations. This process leads to a solution that avoids decision and combines best possible choices.

TABLE (4) IS THE RUBRIC THAT WAS EXTRACTED FROM OWEN`S DESIGN THINKER`S CHARACTERISTICS.

DESCRIPTION	LEVEL 1	LEVE 2	LEVEL 3
Human-Centered. Designer must continually consider how what is being created will respond to human needs.	Doesn't consider human needs while addressing problem solution.	Occasionally consider human needs while addressing problem solution.	Continuously consider human needs while addressing problem solution.
Ability to visualize. Designer works visually	Doesn't communicate visually	Designer uses visual communication in some steps.	Designer visualize every step.
Predisposition toward multi functionality. Designer should look at different/multiple solutions to a problem and keep the big picture of the problem in mind while focusing on its specifics	Solution addresses the problem from just one side.	Solution addresses the problem from two different aspects.	Solution addresses the problem from multiple sides.
Systemic vision. Designer should treat problems as system problems with opportunities for systemic solutions involving different procedures and concepts to create a holistic solution	Process doesn't involve systematic procedure.	Process includes more than one step to reach solution.	Process is systemic that involves different procedures to reach a holistic solution.
Ability to use language as a tool. Designers should be able to verbally explain their creative process forcing invention where detail is laking and expressing relationships not obvious visually	There is no ability to use language as atool.	Limited ability to use language as a tool.	Designer is able to verbally explain their creative process forcing invention where detail is laking and expressing
Affinity for teamwork. Designers need to develop interpersonal skills that allow them to communicate across disciplines and work with other people.	Work on problem is individual.	Difficulties to work in team.	Work is done in teamwork that contain multidisciplinary personnel
Avoiding the necessity to choice. Designers search competing alternatives before moving to choice making or decision making. They try to find ways to come up with new configurations. This process lead to a solution that avoids decision and combining best possible choices	Solution addresses one side of the problem	More than one solution generated however they or not complementing each other and lead to a choice between them	This process lead to a solution that avoids decision and combines best possible choices.

TABLE (5) DESIGN THINKING 3 PHASES EVALUATION RUBRIC.

DESCRIPTION	LEVEL 1		LEVE 2		LEVEL 3	
Inspiration	No identification of the design problem nor the context.		Weak identification of the design problem and the context.		Good identification of the problem and the context.	
Ideation	The team was unable to synthesize and generate ideas and solutions based on what they have learned from the inspiration.		The team was able to synthesize and generate limited number of ideas and solutions based on what they have learned from the inspiration.		The team was able to synthesize and generate many ideas and solutions based on what they have learned from the inspiration.	
Implementation	No action plan generated.		Unclear action plan generated.		Best ideas generated is turned into action plan.	

2. Problem solutions.

After finishing the sessions, there will be two different outcomes for each problem, the traditional method solutions, and the Design Thinking solutions.

The main objective of this research is to compare each problem's solutions in order to find out if any enhancements occurred.

To Compare these solution some criteria were chosen:

- Unifications required to be done, number of solutions need to be the same consequently the base of the quantitative comparison would be alike.
- The participants will do evaluate the solutions after finishing the sessions, in order to guarantee that the solutions will be compared by the same point of view.
- The evaluation form will not be identified by their method, thus, the participants will not be biased to any of them.

- 5 Criteria were selected to evaluate the solutions ,these criteria are;

- *Applicability,* Which means the solutions that are applied within the current and available resources remain within the Construction manager`s authorities.
- *Innovative,* which means the solution is considered a new and creative idea.
- *Scalability,* which means that the solution are developed to a better answer that should be good enough to be built up on it.
- *Addresses the big picture,* This is an important characteristic of Design Thinking, as it looks at the problem from a wider spectrum and tries to connect different aspects of the problem; the participant has to evaluate the solution based on this aspect.
- *Direct impact on the problem,* this criterion is designed to make sure that the participant did understand the problem brief and acted based up on that.

These 5 criteria should be evaluated numerically, the participant should give a score from 0, 1 or 2 on, for each one of the 5 solutions, Therefore, each criteria will be evaluated from 0 to 10 and accordingly each solution will be evaluated from 0 to 10. This format will enable a clear comparison between solutions and criteria, since they will all have the same system of evaluation. Table (22) shows a template of the solutions evaluations.

3. Participants involvement and interaction

The third area needed to be investigated is the interaction between the participants, and whether or not the process of Design Thinking adds to their knowledge, would they adapt it in the future, and would they be interested in further training on Design Thinking, which is based on their experience during the sessions or not.

The answer of these questions would help the research focus on the area of development in training and education.

3.7 CONCLUSION

The main purpose of the designed experiment is to extract as much data as possible from the participant's activities, therefore, the experiment was planned to be simple and to help participants concentrate on their task. All aspects, starting from the venues up to the materials of the evaluation rubric, were all built on the same concept.

CHAPTER 4

The Experiment

4.1 Introduction

This chapter covers the experiment application and its steps, it describes the experiment's sessions and emphasizes samples of the materials output.

In brief, the experiment was conducted in four sessions; the first session covered the three problems in the traditional method of thinking. While each one of the three other sessions covered one problem only by implementing the Design Thinking methodology.

The second session was the longest; it included an introduction to Design Thinking and its methodology as well as solving the first problem, while, the last two sessions were relatively short, in which the participants already gained the knowledge of Design Thinking skills and tried to implement it. The final part of the experiment was the questionnaire and the evaluation forms that the participants filled.

4.2 Pre-experiment

The pre-experiment phase included all the preparations for the experiment, which are:

- A motivational video for the participants, this video gave an idea about an assignment done by the IDEO team to redesign a shopping cart using Design Thinking methodology. The main purpose of this video was to show the participants a real life application of Design Thinking. It called attention to the importance of this science in inspiring teams and provoked them to be innovative and creative. (https://youtu.be/M66ZU2PCIcM)

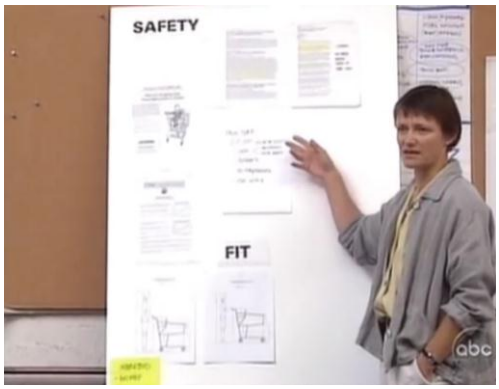


IMAGE (1, 2) CAPTURED FROM IDEO DOCUMENTARY VIDEO.

- The Design Thinking handout, included explanation for the three phases of Design Thinking and sample tools for each phase. This hand out was used as a guide for the participants, during each session. Knowing that the participants will not have a full command of Design Thinking after the first session, this handout was used as a reminder

and a guide through the different steps of Design Thinking, as we proceeded in our experiment.

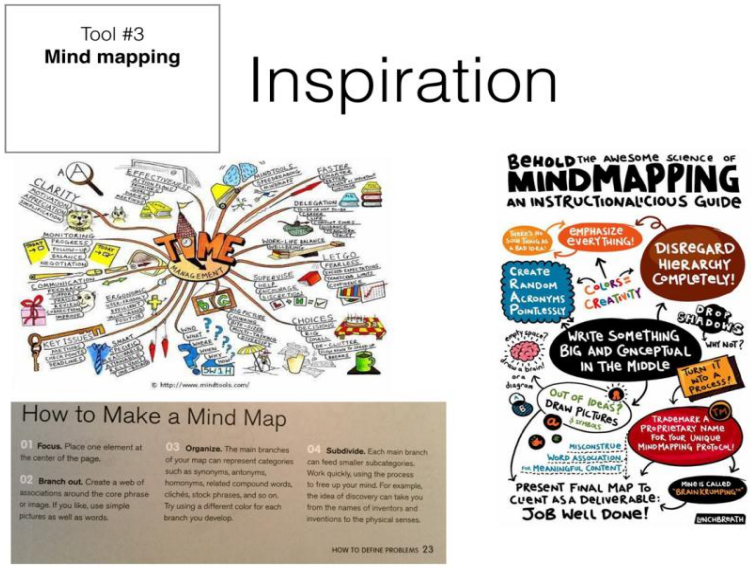


FIGURE (7) SAMPLE OF HANDOUT PRESENTED TO THE PARTICIPANTS.

- Stationary, this represented the tools that the participants used during the experiment. We provided; a set of coloured pens and markers, coloured post-it notes, white board, flip chart and A4 white sheets.
- Finally; the preparation of the location to accommodate 20-25 persons.

IMAGE (3) STATIONARY USED IN THE EXPERIMENT.

4.3 Session 1

This was the introductory session; the purpose of this session was to collect problem solutions from participants according to their traditional thinking method (role-of-thumb), therefore, it did not require any previous knowledge about Design Thinking.

In the beginning, the participants had an orientation to focus on the problems from their original perspective; it was a 10 minutes briefing about decision making in construction and its importance. They were asked to work individually to solve these problems within their authorities as construction managers, and to try to explain as much as they can the methodology and plan that they used to solve the problems.

Fifteen minutes was the given time to solve each problem, however, most of the participants finished before the allocated timing. They took from 10 to 12 minutes in average to solve each problem. Solutions were collected after each problem separately with a 5 minutes break between them.

IMAGE (4) PARTICIPANTS WORKING ON PROBLEM SOLVING IN SESSION 1 (WORKING INDIVIDUALLY).

4.4 Session 2

This session was the longest, in which the Design Thinking crash course took place, and participants were introduced to Design thinking as a new approach for solving problems.

The session started with an introduction about Design Thinking, followed by an eight minutes video presentation about the application of Design thinking in product redesign.

The Video showed the team of IDEO - an international design firm- redesigning a shopping cart, using the Design Thinking methodology. The video was interrupted by some questions from participants who are trying to understand the process.

After presenting the video, the methodology of the Design Thinking process was explained with its three phases; Inspiration, Ideation and Implementation.

IMAGE (5) INTRODUCTION TO DESIGN THINKING SESSION.

Participants were asked to go through one phase at a time, which means that they had to finish the inspiration phase, followed by the Ideation phase and finally the Implementation phase, in order to build each phase based on the outcome of the previous one. This sequence assures that the participants would understand the required output of each phase, and build on the outcome for the next phase.

Subsequently, participants were divided into 9 groups of 2-3 people, after being briefed by problem (A) they started working on the problem definition by using the given tools, which were presented in the venue.

Phase one- Inspiration- took duration of 25 minutes. Afterwards, they were engaged in phase 2, which was solving the problem by applying the concept of –ideation- using many tools that enabled them to generate multiple direction ideas based on the problem definition they created.

Finally, in phase 3 participants started forming problem solutions through - Implementation -. At the end of the session each team handed their problem solution in a set of A4 sheets, they were encourage to try to visualize their process and solution using

sketches, colouring along with post-it notes.teams who asked for more time were granted 5 extra minutes, while the rest finished in the allocated 25 minutes for each phase.

After finishing this session, participants were interested to learn more about Design Thinking and its possibilities and they were engaged in discussions sharing their opinions. The following images (6, 7, & 8) show small teams engaged in discussions; the teams were formed from different people with diverse disciplines.

IMAGE 6 TEAMS ENGAGED IN DISCUSSIONS (INFRA-STRUCTURE MANAGER (RIGHT)AND LAND SCAPE SPECIALIST)

IMAGE 7 (LEFT), TEAMS ENGAGED IN DISCUSSIONS (ARCHITECT (RIGHT) AND CIVIL ENGINEER)
IMAGE 8 (RIGHT),TEAMS ENGAGED IN DISCUSSIONS (ARCHITECT RIGHT AND SURVEYOR)

4.5 Sessions (3 & 4)

On the third day of the experiment, the participants have worked to solve problems (B) & (C). Both sessions (3,4) were done in one day to save participants' time. A 30 minutes break was granted between the two sessions, in order not to make extra load on them.

These two sessions where similar to session one, except they did not require repetition of the crash course, as they gained enough knowledge from the previous session; however, they needed to refresh their information about the phases of the process. Teams were free to switch their members, yet; only three teams exchanged members, while the rest stayed in their teams as session (1).

Participants showed more understanding of Design Thinking in session (3 & 4), as they were engaged in more detailed discussions, trying to have more ideas and more points of view. They showed more command of the tools used, however, they were still asking for help in some aspects, which in turn needed more elaboration and explanation.

Sessions (3 & 4) were also characterized to be more human centered- an important aspect of Design Thinking- as the participants started to focus more on workers problems, what are they looking for and what can make them do their jobs in a better way. Some participants started to recall their experience with workers and how each group behaves differently according to their origin, which is affected by their culture. Those remarks were raised during the discussions; as they realized that, they could use them as a key to problem solving, although they previously considered them obstruction to on-site problems yet Participants have realized that some challenges represent an opportunity to solve some problems, and thus lead to creative solutions.

IMAGE 9 (ABOVE LEFT), 10 (ABOVE RIGHT), TEAMS ARE WORKING VISUALLY USING STICKY NOTES AND COLOURED GRAPHS.

4.6 General Notes

- During all sessions, photographing and video recording took place to make sure that each step of the experiment is documented, either to get more information or to use it as a reference during the analysis and evaluation.

- During the first session; traditional thinking- participants didn`t ask for any help or clarifications except for; the time allowed for each problem and whether or not they are required to solve the three problem together?

- During the Design Thinking sessions, Sometimes, discussions were collective, not within the same team only but also between different teams. Participants were not allowed to share opinions, except during the inspiration phase only, accordingly, teams were asked to concentrate on internal discussions during the Ideation and Implementation phases so that they will not affect each other's judgments.

- After Design Thinking sessions, some of the participants were engaged in discussions about how to use this approach in other problems they are regularly facing, they named some problems that they need to work on and to held more workshops to find solutions.

- Participants were interested to know how did these solutions fare in respect to each other's openion, which means working in teams created a competition for having a better solution.

- The following images (11-15) show samples of the output after the different sessions. A noticeable clear difference can be detected between session 1 (images 11-12) and the other sessions (images 13-15), were the participants started to use different tools (brainstorming, mind mapping and back casting) among other tools, while they were just descriptive in their solutions in session (1) without using any tools.

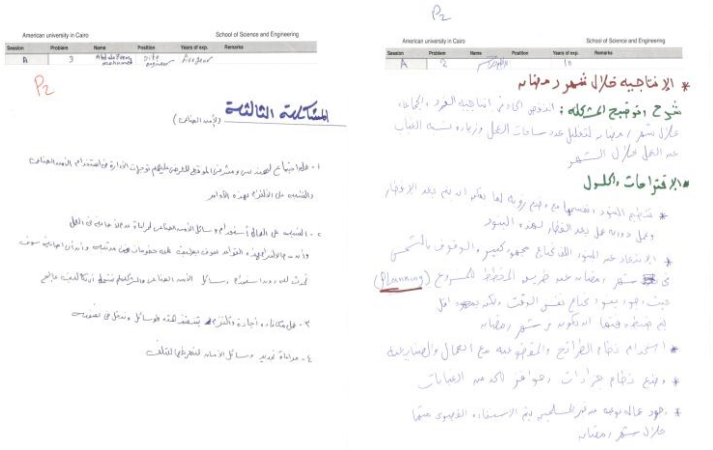


IMAGE 11 (ABOVE), 12 (ABOVE RIGHT). SAMPLES OF OUTPUT DELIVERED BY PARTICIPANTS AFTER SESSION 1.

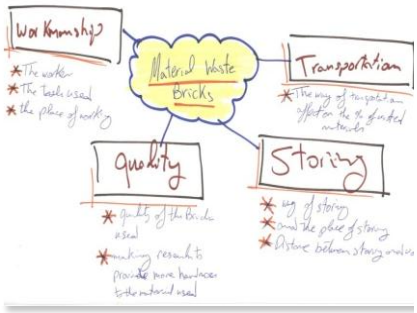


IMAGE 13. A GROUP USING MIND MAPPING TOOL IN SESSION 2

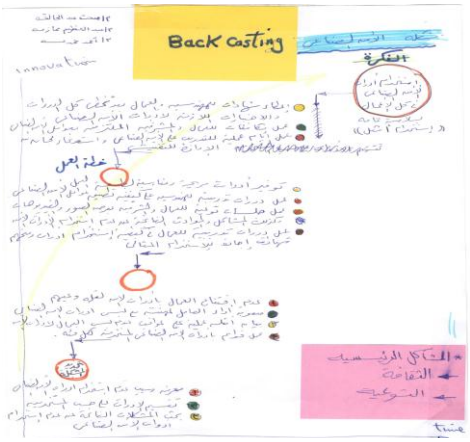


IMAGE 14 (ABOVE RIGHT). A GROUP USING BACKCASTING TOOL IN SESSION 3
IMAGE 15 (ABOVE LEFT). A GROUP DOCUMENTING THEIR BRAIN STORMING IN SESSION 4.

4.7 Questioner and Evaluation

After finishing the four sessions, further steps needed to be done; First, studying the impact of the experiment on the participants, seeing if it had helped in problem solving, if they are interested to have further training and Did they feel it is more efficient than their traditional method of thinking?.

It was also essentiall, after finishing the sessions to know whether the participants had any previous knowledge about Design Thinking, and did they have any experience using the tools they used in the experiment.

Second, it was important that participants evaluate both solutions by themselves to give balance in the evaluation process, thus when participants evaluate both methodology solutions- traditional and Design Thinking- they would realize the difference happened in their mindset.

Participants were given the questioner sheet with the evaluation sheets attached to it; solutions were not labeled with their methodology of thinking, in order not to be biased to any direction. Participants spent around 15 minutes evaluating the solutions, they did it individually so they wouldn't affect each other`s decisions.

4.8 Conclusion

This chapter presented the activities that happened during the experiment, the different sessions and the outcomes of the problem solutions. It also went through the different steps the participants have done according to the planned experiment design; however, some minor modifications happened during the activities as described in the general notes. In conclusion, the data collected from the experiment were satisfactory and gave enough indications towards answering this research questions.

CHAPTER 5

Experiment Analysis

After finishing the experiment, materials were collected to start extracting and analyzing data. There were three types of information collected from the experiment; observations during sessions, problem solutions provided by the participants, and finally, questioners filled by the participants.

Data was extracted from those three types of information, and were analyzed quantitatively and qualitatively.

5.1 Data collection

5.1.1 Observations

During and after each session, data was recorded through notes, pictures and video recording, these notes are:

- In session (1) participants did not ask for elaborations on problem.
- In session (1) participants finished the assignment before the allocated time finishes.
- At the beginning of session (2) few participants were engaged in the discussions (3 persons).
- Throughout watching the video, more participants started to engage.
- When they started to solve problem (A), participants started to ask for more elaborations of the problem unlike session (1).
- Some participants started to ask to extend the time allowed for each the Design Thinking phase.
- Some participants wanted to be in larger groups (more than 2).
- One group decided to have privacy while working but the rest was comfortable sharing information with other groups.
- After the sessions, participants were interested to know more about Design Thinking, and they asked for other future sessions in order to discuss some other problems they regularly face while working on site.
- Participants expressed their joy of interacting with their colleagues in different context despite discussing business problems.

5.1.2 Photography and Video recording

The purpose of the photography and video recording is to document the experiment and to extract more data to help us to have a better picture of the results. Photos were taken during sessions to record participant's interaction and communication with each other as well as recording each group's behavior. These recordings gave answers to some questions like, was everyone engaged? Were participants interested to try a new method of thinking?

5.1.3 Problem solutions collection

In Each session, the Participants delivered their input on A4 documents, about 21 individual sheets in session (1) and the sum of 25 group work documents in the other three sessions. Then, the documents were sorted by problems; each problem had a group of solutions, some were in the Traditional Thinking method and others were in the Design Thinking method.

5.1.4 Questioner

After the four sessions, participants filled a questioner along with an evaluation form. The questioner gave an idea about participant's knowledge of Design thinking and its tools; it also gave a general feedback to evaluate their opinion on using design thinking in problem solving. At the same time, the evaluation forms allowed us to rate each problem's solution, as each participant was asked to give every solution a numeric evaluation (0,1 and 2) in order to determine whether or not an enhancement happened to the problem's solution due to the change of the method of thinking.

5.2 Data extraction

The solutions in each of the four sessions were collected and the process of extracting data were done according to the following criteria:

5.2.1 Problem solution

The collected solution from all sessions were documented, and similar solutions were gathered to avoid receptions. The number of solutions was limited to 5; this restriction of numbers of solutions enable us to compare them qualitatively. This comparison allow us to determine whether there was an enhancement in the problem solving process or not. The following tables represent the final solutions of problems A, B and C.

Table 6. Problem (A) solutions.

	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5
Traditional method	Splitting day into to shifts early morning for light tasks and evening one one for harder tasks.	Pay per task.	Classifying workers to fasting and non-fasting to be able to distribute tasks fairly.	Arranging group breakfast/soh our for site personnel and also arranging awarness sessions.	Ramadan to be the annual leave for all personnel and postpone works.
Design Thinking	Splitting day into two shifts and classifying team according to the residence proximity to site location.	Splitting Ramdan into 3 periods 10 days each, and each workers group works full day.	Tasks that doesn't need high quality supervision to be put on night shifts.	Controlling site electricity feeds to prevent works from spending too much time watching TV.	Holding sporting and social activities to resident personnel.

TABLE (7) PROBLEM B SOLUTIONS.

	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5
Traditional method	Monitoring block stacking process and insuring site preparation for easy maneuvering.	Insuring quality control on each phase of the process.	Making sub-contractor and supplier accountable for brick waste.	Recycling bricks waste.	Verifying quantities before ordering.
Design Thinking	Studying orders history and observing waste ratios so we can control it.	Recycling in one of these activities: concrete works, underground cable protection or landscape works.	Applying QC plan that contains: monitoring delivery trucks to avoid pumps on roads, frequent visits to supplier factory and maintain site Cleaning.	Applying rewards and penalty system for the lowest and highest waste ratio team.	Technical office to double check purchase orders with drawings and quantities before placing orders.

TABLE (8) PROBLEM C SOLUTIONS.

	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5
Traditional method	Increase awareness and make training to project team.	Applying penalty and reward system.	Monitoring system with team in uniform as policemen.	Spreading rumors that there will be law suits against who doesn't oblige to the regulations.	Making life insurance on personal instead of investing H&S supplies and regulates.
Design Thinking	Increase awareness by showing videos of dangerous incidents and assuring workers are an important asset for the company.	Studying the nature of each trade to make sure that workers are comfortable while working, and noting that low quality supplies will affect the efficiency of work.	Gradually applying H&S regulation to set an example and benefiting from compitition between different group of workers.	Giving rewards and appreciation certificates to encourage the teams to excell	Making sure not to rotate workers too much until they settle on the new system so we can have better results.

5.2.2Keywords

The second information that was extracted out of the delivered problem's solutions are the keywords used; the participants used some keywords during each session, which helped them make their decisions during problem solving.

There were common key words used in the traditional method of thinking process and others in the Design Thinking.

In problem (A), the traditional way of thinking generated seven keywords, while Design Thinking generated 20 keywords. The new keywords indicate a better focus state from the teams in the Design Thinking sessions; words like "Addiction to tea, coffee and

tobacco" and "Time management" appeared in team's discussions, which indicate a shift in their mind set.

The same happened in problems (B & C); seven keywords were presented in the traditional session for problem (B), while 13 keywords in total were presented in the Design Thinking session discussing the same problem. New key words like "Worker's comfort" and "Cheap supply" were used to indicate that the mentality of the workers had to be considered while discussing a new subject concerning them. In problem (C) Health & Safety is a big issue that mainly concerns workers on site, yet, problem (C) produced nine keywords in its Traditional Thinking session while they increased to 16 keywords in its Design Thinking Session.

The following tables show the keywords that were repeated in both methods and the keywords that were used during Design Thinking sessions only.

TABLE (9) PROBLEM (A) KEYWORDS.

Repeated Keywords	Design Thinking only Keywords
Lead by example	Addiction to Tea & Tobacco
Payment System	Climate Effect
Penalties	Cultural Misconception
Planning	Hunger
Psychological Aspect	Food Quality
Targets	Lack of Concentration
Transportation	Laziness
-	Lead by Example
-	Non-fasting Workers
-	Sharing Opinions with Team
-	Social Activities
-	Time Management
-	TV & Electricity Control
7	13

TABLE (10) PROBLEM (B) KEYWORDS

Repeated Keywords	New Keywords
Awareness	Comfort of Workers
Bonus/ Rewarding	Cheap Supplies
Checkpoints	Lack of Education
Demonstration	Loyalty
Monitoring	Society Culture
Panalties	workers Behaviour
Training	-
7	6

TABLE (11) PROBLEM (C) KEYWORDS.

Repeated Keywords	New Keywords
Quality Control	Testing
Recycling	Awareness of Recycling
Standard Dimensions	Applications of Recycling
Trained personnel	Research
Planning	Roads Conditions
Automation	Manufacturing Process
Standards of Brick Staking	Wooden Plates
Penalties	-
Bonus/ Rewards	-
9	7

5.2.3 Number Of Tools Used

While presenting the concept of Design Thinking, some of its tools were explained to participants, next they were asked to use whichever they see suitable and would enable them to build their decision.

After gathering the problems' solutions, the number of tools used in each session was counted in order to know how much did the participants understand the concept of Design Thinking. Also the number of times each tool was used will help determine the relationship between the Design Thinking tools used and the amount of enhancement that could be achieved in problem solving.

The following tables indicate how many times each tool was used, and the total number of times Design Thinking tools have been used in each phase.

TABLE (12) NUMBER OF TOOLS USED IN EACH PROBLEM.

Used Tool	Problem A	Problem B	Problem C	Total
Activity Time Chart	5	0	0	5
Backcasting	2	2	3	7
Brain Storming	10	9	9	28
Empathy Map	3	0	0	3
Goal Grid	3	1	1	5
Mind Mapping	7	9	8	24
Mock Ups	0	2	0	2
Scinarios	1	0	0	1
Swot Analysis	1	1	1	3
Total	32	24	22	78

TABLE (13) NUMBER OF TOOLS USED IN EACH PHASE OF DESIGN THINKING.

	Problem A	Problem B	Problem C	
Inspiration	17	13	12	42
Ideation	10	7	8	25
Implementation	5	4	2	11
Total	32	24	22	78

5.2.4 QUESTIONAR

From the questioner we could extract important information as follows;

- Number of participants having previous knowledge of Design Thinking.
- Number of participants having previous knowledge of any of the Design Thinking tools and the name of these tools.
- If the participants find Design Thinking a helpful method in problem solving, did it help them make a better decision, and are they willing to have more training to improve this skill?
- Number of participants willing to adapt Design Thinking in their future decision-making.

TABLE (14**) QUESTIONER RESULTS.**

	Yes	No
Do you have previous knowledge of Design thinking? هل لديك معرفة سابقة بال Design Thinking.	10	10
Do you have previous knowledge by any of the use tools (brain storming, mind mapping,.... Etc) هل كان لديك اي معلومات سابقة عن اي من الادوات المستخدمة في التجربة ؟	10	10
Do you feel that Design thinking has helped you to see the problem in a better way? هل تري انك استطعت النظر للمشكلات التي تعرضت لها في التجربة بشكل افضل من طريقتك التقليدية؟	20	0
Are you interested in more training on Design thinking? هل انت مهتم ان تتلقي تدريب اكثر علي Design Thinking	16	4
Do you feel it can help you make better decisions? هل تري انه ممكن يساعدك في صناعة القرارات بشكل أفضل ؟	20	0
Do you feel you can adapt this method into your organization? هل تري انك تستطيع تبني هذه الطريقة لحل المشكلات التي توجهك اثناء العمل ؟	20	0

5.3 Data Analysis

The extracted data produced an amount of information that needs to be analyzed to answer the main questions of this research; which is the quest of knowing if there is a systematic way to enhance construction site engineers creativity and accordingly to enhance their problem solving techniques?, Is there a tool to measure this enhancement if there is any? Are site engineers able to be trained to systematically stay more creative?

The information consists of Participants evaluations, number of keywords created in each session, number of Design Thinking tools used and the evaluation of the Design Thinking process.

5.3.1 Problem Solutions Analysis

The solutions collected from each problem (traditional and Design Thinking) were given back to the participants to evaluate. There were five criteria of evaluation

Applicability: the provided solution should be applicable based on the participant`s experience.

Innovation: the participant should evaluate how innovative the solution is; whether it`s a new approach to the problem or a representation of repeated solutions.

Scalability: Does the participant see the solution scalable?

Direct Impact on the problem: Does the solution have a direct impact on the problem or not?

Addressing the big picture: Does the solution address the problem from more than one side?

The Participants were asked to evaluate each criteria with grades of 0, 1 or 2, accordingly this will make the best evaluation take 10/10 and the worst 0/10 which makes the comparison and scaling easier for the participants and for analysis purposes as well.

The evaluations were collected in tables, and then the average and standard deviation were calculated. A comparison graph was plotted for the average grade of each criteria of the traditional and Design Thinking methods for each problem. The following tables and graphs show the results of these comparisons.

TABLE (15) **PROBLEM A TRADITIONAL METHOD SOLUTIONS EVALUATIONS.**

	Applicability	Innovation	Scalability	Addresses the big picture	Direct impact on the problem
1	4	6	4	4	6
2	4	5	6	5	5
3	7	4	5	4	6
4	4	3	2	2	3
5	6	8	6	5	6
6	6	5	2	4	6
7	5	5	4	4	5
8	7	6	7	7	6
9	5	2	2	1	2
10	4	4	2	4	5
11	4	6	8	5	7
12	4	5	6	7	7
13	7	6	6	4	6
14	4	5	5	5	6
15	5	5	5	5	6
16	8	6	5	5	9
17	4	5	6	6	7
18	7	3	4	5	5
19	6	6	0	7	6
20	6	6	5	5	4
AVG/ trad	5.35	5.05	4.5	4.70	5.65
STDEV	1.35	1.36	2.01	1.49	1.50

TABLE **(16) PROBLEM A DESIGN THINKING SOLUTIONS EVALUATIONS.**

	Applicability	Innovation	Scalability	Addresses the big picture	Direct impact on the problem
1	8	6	8	6	6
2	8	6	9	7	8
3	5	3	4	3	3
4	4	4	4	3	3
5	9	10	8	8	7
6	7	4	7	4	4
7	6	4	7	5	5
8	6	6	6	6	6
9	6	4	4	3	5
10	7	3	4	5	5
11	7	7	7	6	4
12	6	7	6	8	7
13	6	5	6	4	5
14	3	5	5	5	5
15	6	7	8	6	6
16	8	7	6	5	6
17	8	8	6	5	5
18	6	6	8	4	9
19	7	7	0	7	9
20	7	8	7	6	5
AVG/ DT	6.5	5.85	6	5.30	5.65
STDEV	1.43	1.84	2.08	1.53	1.69

TABLE (17) PROBLEM B TRADITIONAL METHOD SOLUTIONS EVALUATIONS.

	Applicability	Innovation	Scalability	Addresses the big picture	Direct impact on the problem
1	7	7	5	6	6
2	7	5	8	5	5
3	7	6	7	5	6
4	7	5	5	5	6
5	9	7	7	6	6
6	6	3	4	3	6
7	6	2	4	2	3
8	8	8	8	8	8
9	6	1	2	2	5
10	8	4	3	7	4
11	7	7	4	6	6
12	6	7	9	9	8
13	6	4	5	3	5
14	5	5	5	5	5
15	9	8	7	6	6
16	8	7	6	5	8
17	3	3	2	3	3
18	6	5	3	4	6
19	8	7	0	5	6
20	6	7	5	4	3
AVG/ trad	6.75	5.4	4.95	4.95	5.55
STDEV	1.41	2.04	2.31	1.85	1.50

TABLE (18) PROBLEM B DESIGN THINKING SOLUTIONS EVALUATIONS.

	Applicability	Innovation	Scalability	Addresses the big picture	Direct impact on the problem
1	8	4	4	4	3
2	8	6	10	9	8
3	7	5	7	5	5
4	7	6	4	4	5
5	8	8	7	7	8
6	7	4	8	5	5
7	6	8	9	4	7
8	9	9	9	9	9
9	7	5	7	4	4
10	8	8	6	4	6
11	8	9	9	7	7
12	9	9	9	9	10
13	6	5	8	5	6
14	7	5	5	5	6
15	8	8	9	5	6
16	10	7	6	6	8
17	8	7	6	8	7
18	8	8	8	5	8
19	8	7	0	8	6
20	7	8	7	6	5
AVG/ DT	7.7	6.8	6.9	5.95	6.45
STDEV	0.98	1.67	2.36	1.82	1.73

TABLE (19) PROBLEM C TRADITIONAL METHOD SOLUTIONS EVALUATIONS.

	Applicability	Innovation	Scalability	Addresses the big picture	Direct impact on the problem
1	9	9	10	9	9
2	6	6	6	4	5
3	9	5	6	5	5
4	9	5	5	5	5
5	10	8	7	6	8
6	6	3	6	5	7
7	5	2	4	2	6
8	9	8	8	8	8
9	8	2	5	2	4
10	9	9	6	8	7
11	4	6	8	5	7
12	4	5	6	7	7
13	9	5	9	5	9
14	8	5	5	5	7
15	5	5	5	5	6
16	9	9	6	7	9
17	8	5	5	7	6
18	9	4	7	7	8
19	10	8	0	8	3
20	8	7	5	6	4
AVG/ trad	7.7	5.8	5.95	5.80	6.5
STDEV	1.95	2.19	2.06	1.88	1.76

Table (20) Problem (C) Design Thinking solutions evaluations.

	Applicability	Innovation	Scalability	Addresses the big picture	Direct impact on the problem
1	10	9	10	10	9
2	9	8	7	8	9
3	8	5	7	5	5
4	9	5	5	4	7
5	9	6	5	5	8
6	5	5	8	5	5
7	7	5	10	6	7
8	9	9	9	9	9
9	9	4	6	4	4
10	7	5	4	5	6
11	7	7	7	4	6
12	6	7	6	8	7
13	9	7	8	5	6
14	6	5	5	5	6
15	6	7	8	6	6
16	8	7	5	6	10
17	6	4	3	6	5
18	6	7	7	4	8
19	10	10	0	6	3
20	8	8	9	7	6
AVG/ DT	7.7	6.5	6.45	5.90	6.6
STDEV	1.53	1.73	2.46	1.71	1.82

Chart (1) Problem (A) solution comparison

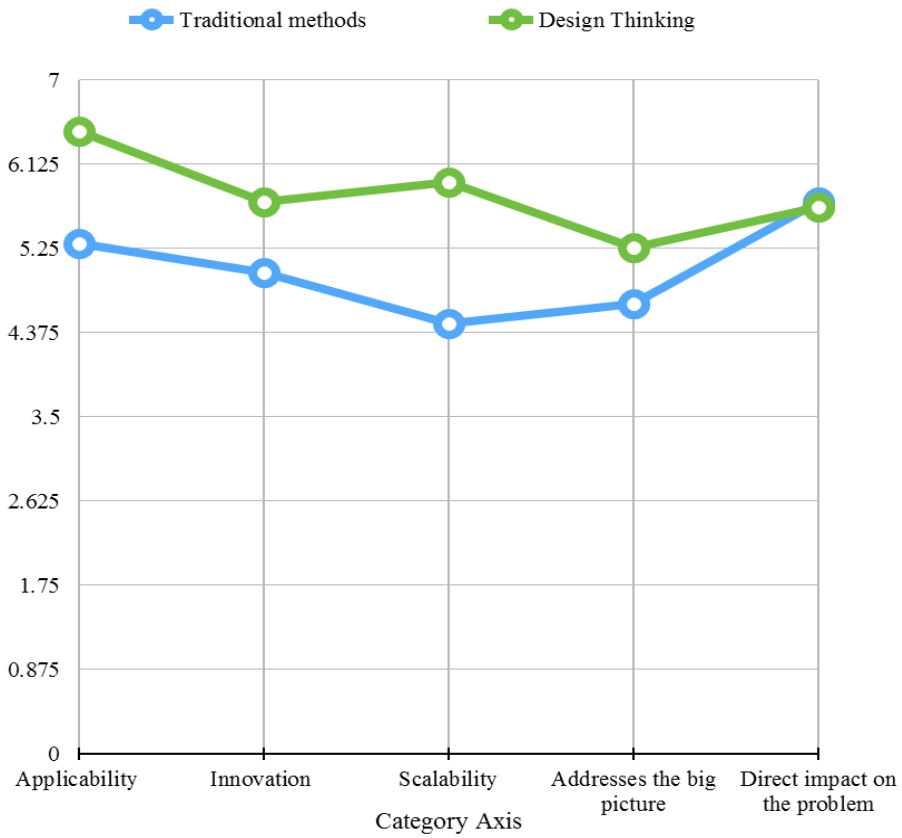


Chart (2) Problem (B) solutions comparison

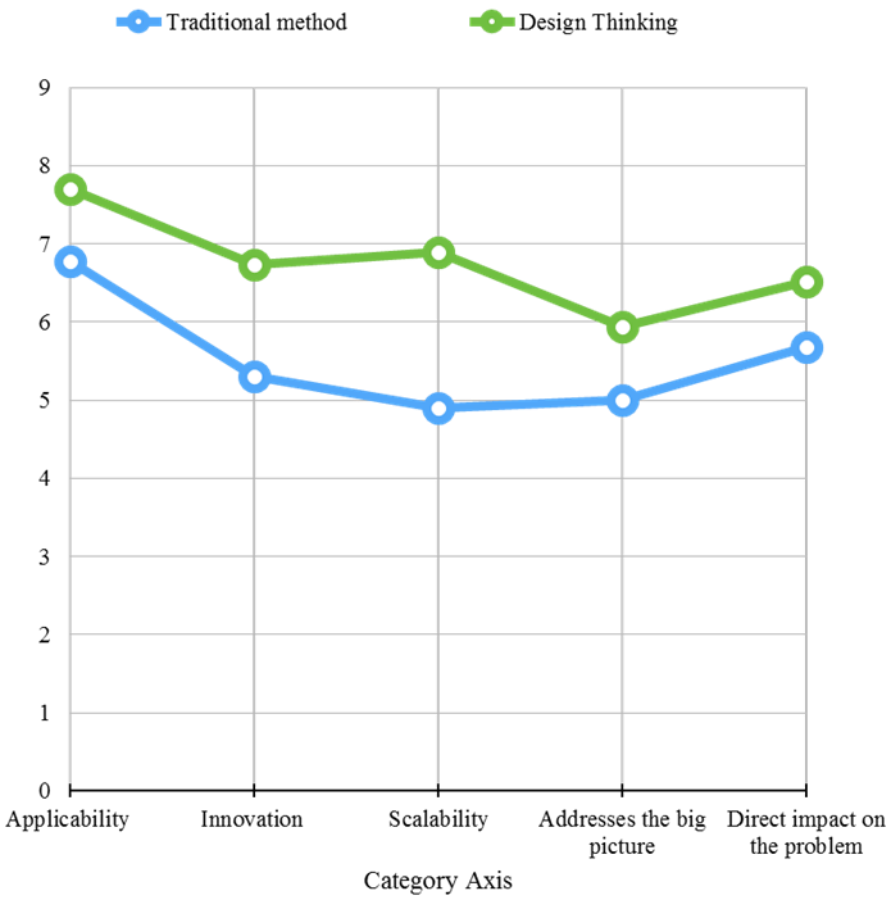
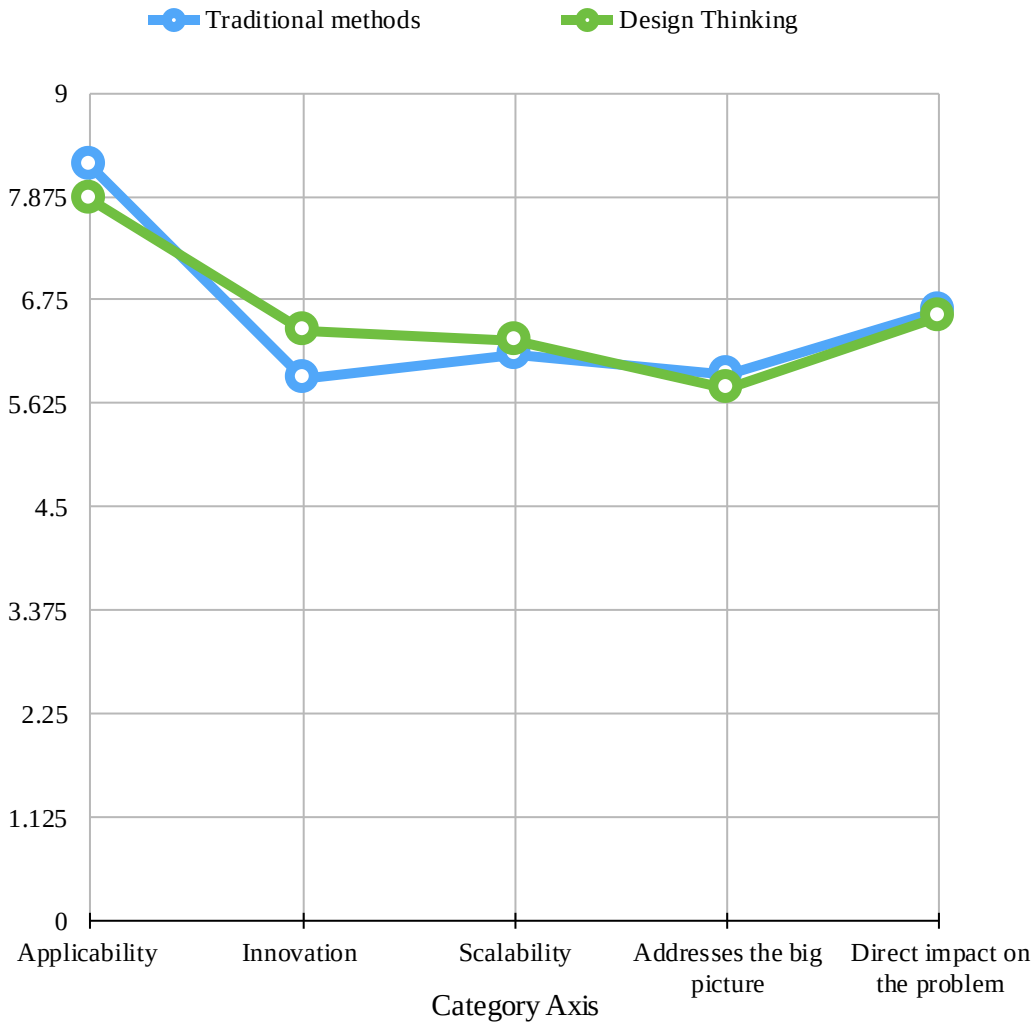


Chart (3) Problem (C) solutions comparison



From the previous comparison tables, we notice that, the enhancement happened on problem solutions that were represented in the shaded area.

We can notice that all the participants gave higher grades for design thinking solutions than traditional ones. Yet, the Value of enhancement differs from a problem to another. This noticeable change of values associated with the number of information from the experiment is summarized in 4 points;

- Methodology of problem solving.
- Type of the problem.
- Number of tools used in each problem.
- Number of keywords generated in the process.

1. Methodology of thinking:

Generally, problems solved using Design Thinking methodology got higher grades than problems using Traditional Thinking ones, furthermore, we can notice enhancement for problem solving using Design Thinking tools, however, this enhancement is not constant as other values can affect it.

2.**Type of problem:**

In general, Problems that the participants used to face on a regular basis had a low score, and participants considered their solutions to be less enhanced. While the new problems scored a higher grade of enhancement.

Participants face problem (C) (the brick waste) almost every day, on the other hand, Problem (B) (Health & Safety introduction) represents a new challenge for them. Problem (B) got the highest enhancement score by the participant's evaluations, while problem (C) got the lowest.

Meanwhile, Participants face problem (A) (Ramadan timing) once a year, they are familiar with it, yet, they don`t face it more frequently. This problem got medium enhancement compared to the two other problems.

3. **Number of keywords**

In each problem's solution, participants used some keywords that helped in finding the answer, however, the number of keywords varied from method to another. It

increases while using Design Thinking. It also varied from one problem to another.

Table 21. Number of keywords comparison.

	Problem A	Problem B	Problem C
Traditional Method	7	7	9
Design Thinking	20	13	16

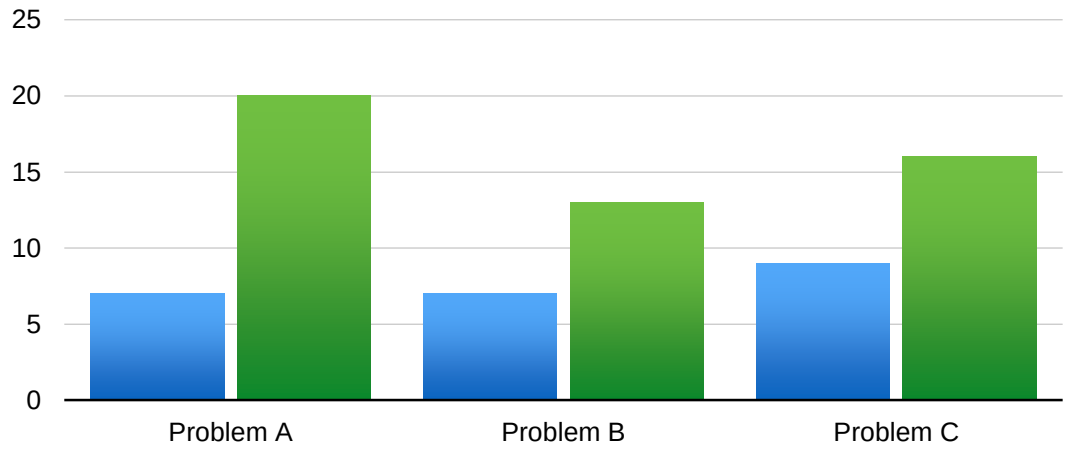


CHART (4) NUMBER OF KEYWORDS COMPARISON

Chart (4) shows that Design Thinking has helped generate more keywords in each problem. Which has a relation with Design Thinking approach, for instance; it helps to view the problem from different angles, using a collective effort from a multidisciplinary team to solve it.

4. **Number of tools used:**

Table 10 shows number of tools used while solving each problem. It`s obvious that problems with the higher number of tools got more enhanced. That`s an indication that Design Thinking tools have a direct impact on the quality of the problem solution.

CHART (5) NUMBER OF KEYWORDS IN EACH PROBLEM COMPARISON.

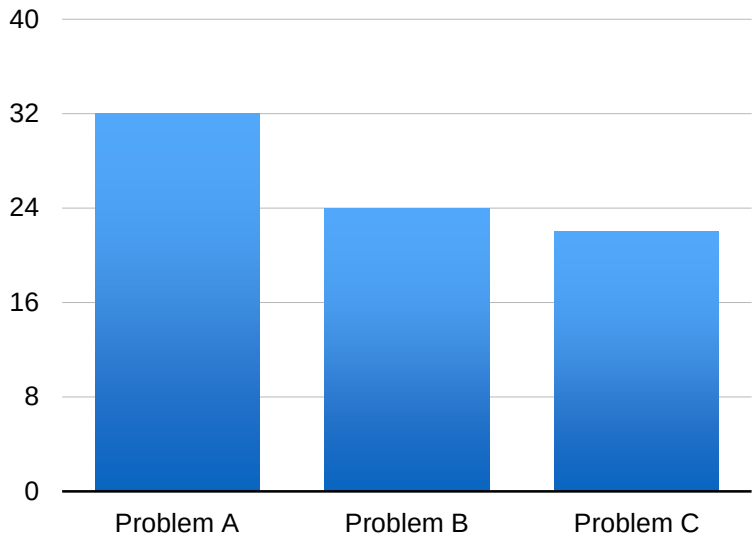


CHART **(6)** NUMBER OF KEYWORDS IN EACH DESIGN THINKING PHASE

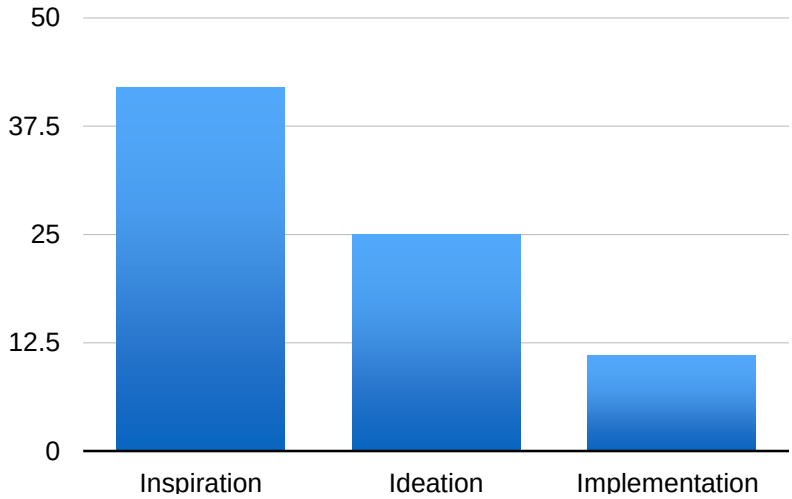


CHART (7) NUMBER OF TIMES EACH DESIGN THINKING TOOL WAS USED

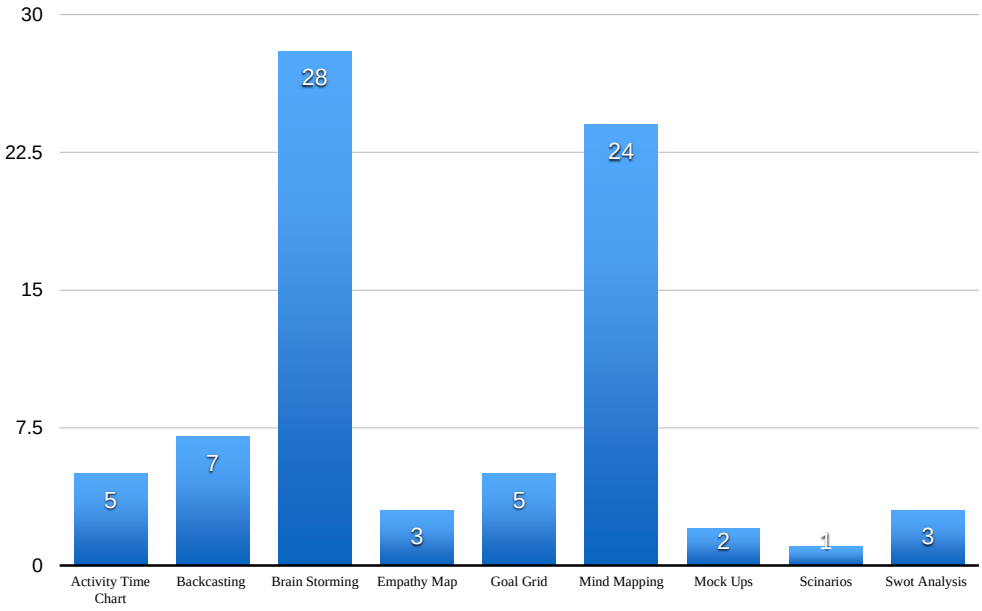


Chart (7) shows the difference in number of times in each Design Thinking tool that was used. It is obvious that participants relied on certain tools (Brainstorming & Mind Mapping) more than other ones, this might be due to the lack of training on using those tools. As a result, we can state that, by training and practicing Design Thinking one should be able to be more experienced in using different tools. Chart (5) shows that the more the number of tools used the more the problem`s solution is enhanced.

5.3.2 Design Thinking process evaluation

The information gathered from the experiment gave us an insight about participant's adaptation to the process. As stated before; the Design Thinking process consists of three phases; Inspiration, Ideation and Implementation. We notice that participants didn`t excel in all phases, Table (13) shows that the number of tools were least used in the Implementation phase. Which means that; if the participants had more training and experience in Design Thinking, results would have been better. A rubric was developed to assess the process and outcome of the experiment; this rubric was built on the characteristics of design thinkers, by Charles Owen (Owen, 2007). The following chart shows the rubric format that was used to evaluate participants input.

CHART (8) DESIGN THINKING CHARACTERISTICS

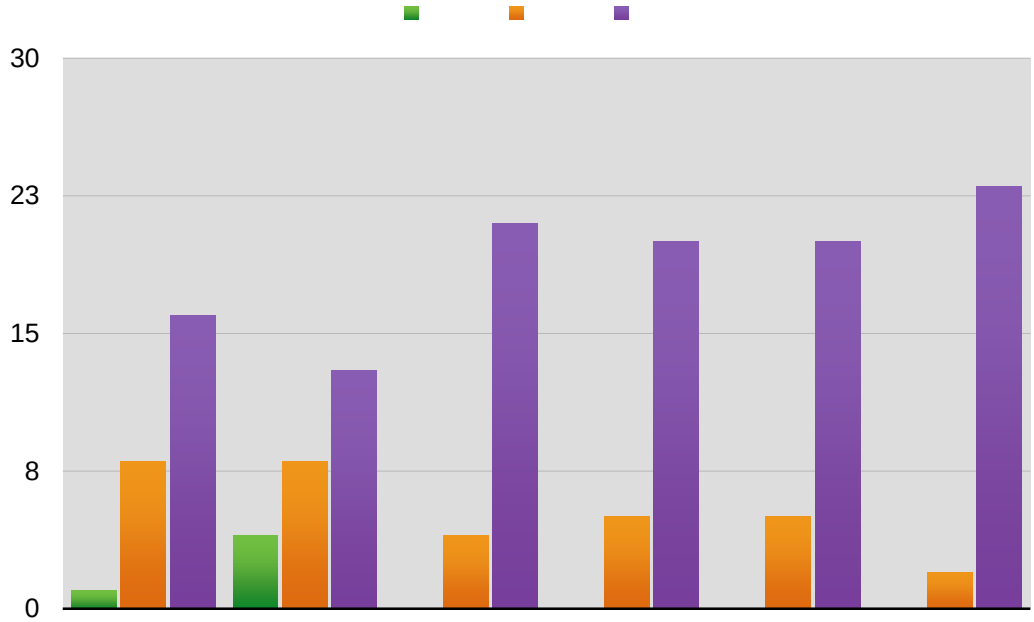


TABLE (22) DESIGN-THINKER CHARACTERISTIC EVALUATION RUBRIC.

	DESCRIPTION	LEVEL 1		LEVE 2		LEVEL 3	
1	Human-Centered. Designer must continually consider how what being created will respond to human needs.	Doesn't consider human needs while addressing problem solution.	1	Occasionally consider human needs while addressing problem solution.	8	Continuously consider human needs while addressing problem solution.	16
2	Ability to visualize. Designer works visually	Doesn't communicate visually	4	Designer uses visual communication in some steps.	8	Designer visualize every step.	13
3	Predisposition toward multi functionality. Designer should look at different/multiple solutions to a problem and keep the big picture of the problem in mind while focusing on its specifics.	Solution addresses the problem from just one side.	0	Solution addresses the problem from two different aspects.	4	Solution addresses the problem from multiple sides.	21
4	Systemic vision. Designer should treat problems as system problems with opportunities for systemic solutions involving different procedures and concepts to create a holistic solution.	Process doesn't involve systematic procedure.	0	Process includes more than one step to reach solution.	5	Process is systemic that involves different procedures to reach a holistic solution.	20
5	Ability to use language as a tool. Designers should be able to verbally explain their creative process forcing invention where detail is laking and expressing relationships not obvious visually.	There is no ability to use language as atool.	0	Limited ability to use language as a tool.	5	Designer is able to verbally explain their creative process forcing invention where detail is laking and expressing relationships not obvious visually.	20
6	Affinity for teamwork. Designers need to develop interpersonal skills that allow them to communicate across disciplines and work with other people.	Work on problem is individual.	0	Difficulties to work in team.	2	Work is done in teamwork that contain multidisciplinary personnel	23

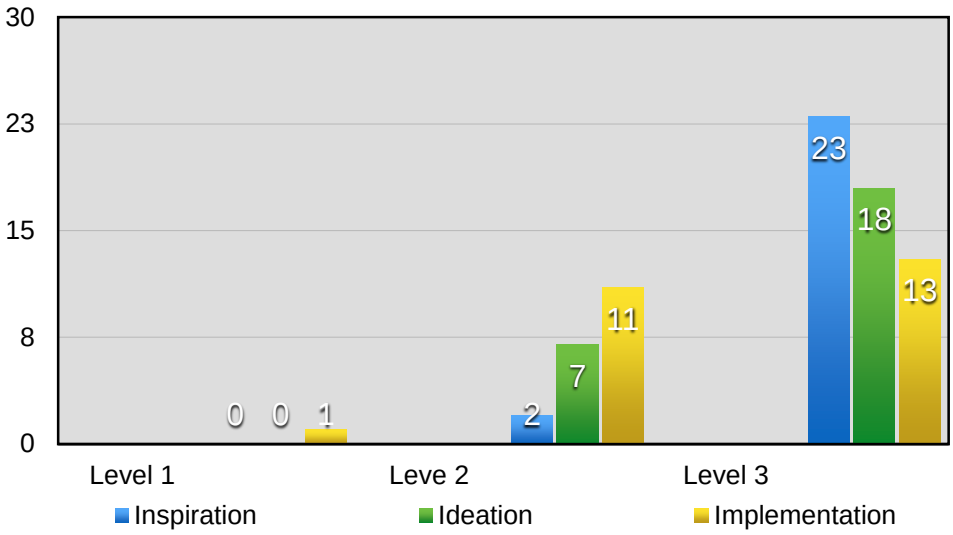


CHART (9) DESIGN THINKING 3 PHASES EVALUATION

TABLE (23) DESIGN THINKING 3 PHASES EVALUATION

DESCRIPTION	LEVEL 1		LEVE 2		LEVEL 3	
Inspiration	No identification of the design problem nor the context.	0	Weak identification of the design problem and the context.	2	Good identification of the problem and the context.	23
Ideation	The team was unable to synthesize and generate ideas and solutions based on what they have learned from the inspiration.	0	The team was able to synthesize and generate limited number of ideas and solutions based on what they have learned from the inspiration.	7	The team was able to synthesize and generate many ideas and solutions based on what they have learned from the inspiration.	18
Implementation	No action plan generated.	1	Unclear action plan generated.	11	Best ideas generated is turned into action plan.	13

The three phases' evaluation rubric shows that the Implementation phase was the least in quality in respect to Inspiration and Ideation phases, therefore, teams needed more training in order to be in more command of their tools, which would help them to originate a solid action plan based on ideas that they have generated in the previous phases.

5.4 Conclusion

Problem solutions have been analyzed on six different levels:

1. The quality of the solutions, which were evaluated by the participants for the Traditional method and Design Thinking method.
2. The relation between the type of the problem and the enhancement of its solution.
3. The keywords generated in each session.
4. Number of Design Thinking tools that were used in each session.
5. Design Thinker characteristics' quality of each group.
6. Quality of each Design Thinking step of each group.

The indications of the previous six steps showed an enhancement in problem solutions through using Design Thinking methodology, and gave us information about the different aspects affecting the quality of enhancement like; the type of problem, number of tools used or keywords generated during the process.

Chapter 6

Conclusion

6.1 Introduction

These days, Design Thinking is adopted successfully worldwide; it entered the field of many industries to generate innovative ideas and created radical breaks. It also gained support due to the success achieved in many other sectors; yet, it is not developed in the construction industry field.

The main purpose of this research is to examine the enhancement that would happen if construction managers adapt design thinking in their decision making instead of using their traditional method of individual intuition. Does the sophisticated nature of construction industry accept a shift in decision-making process? Furthermore, what does it require to achieve this transfer in the process of construction industry?

6.2 Conclusion

Results gained from the experiment gave us some important indications about adapting Design Thinking in construction site problem solving. The comparative analysis results showed that significant improvements happened to solutions generated by Design Thinking approach.

Participants had the ability to understand and apply Design Thinking tools while solving problems; they could work on a more accurate problem definition that considers different aspect of the problem and generates various ideas addressing it.

Moreover, Design Thinking has helped participants generate new keywords that help them study the problem from a bigger spectrum. However, their ability to form the final plan of the solutions need more training in order to offer a more clear and complete solution. The analysis shows that the participants used more tools on step 1 &2 (*Inspiration and Ideation*) more than step 3 (*Implementation*), therefore, the quality of the result would have been more enhanced if participants developed their skills for the final phase.

The results indicate that applying Design Thinking can be successful in the Construction Industry, as it proved success in other industries reviewed in this research, especially, that the users believed that it could help them work on the problems they face on site.

The results showed that the response for different problems varies. Problems that users are used to face more, have scored less enhancement points, while relatively new challenges accept more enhancement points. That notice can help us while putting a strategy for

applying Design Thinking, as each problem might have different nature, behavioral and cultural aspects, which have a great impact on the problems as well.

The experiment gave us two more indications; first, working on problems in teamwork helped achieve better results, second, we noticed that the more the team is diverse the better the outcome.

Site management might seem to be the responsibility of the site manager and site engineer, however, we can`t discount other personnel experience such as technical office, designer, surveyor, accountant and supervisors. Leveraging on group ideation can generate radical breaks and that`s where innovation happens, over and above, feeling the shared responsibility in problem solving raises morals in project team which is a great added value for Design Thinking sessions. The other indication that we deduced is that activities on site generate lots of information every day, capturing this information by taking notes, photographical documentation or video recording can help to develop the work on site. This captured information can indicate patterns, Alarm for growing problems or even inspire new ideas to develop workflow and activities on site. In conclusion, the experiment gave the following information:

- Design Thinking has helped enhance the construction site in problem solving.
- Quality of enhancement was related to the type of the problem.
- Quality of enhancement was also related to the number of Design Thinking tools used, therefore, more research need to be done on the ability to choose tools that suits the nature of the construction industry.
- Participants responded positively for adapting Design Thinking as a new problem solving method, however, more training and education need to be done.

6.3 Limitations

Due to the nature of the research and limitation of participant's time; the experiment was done on four sessions only, Although, The process would take more time in order to allow participants to make their own search and collect more data, yet, the results of the experiment are encouraging for more developments.

6.4 Recommendations

6.4.1 On Research Level

Design Thinking is relatively a new topic, however, It is gaining much attention recently. For instance; this research is one of the few efforts addressing Design Thinking in construction industry, therefore, there are many areas yet to be studied to improve the model of Design Thinking, and to observe if there are modifications that suits construction management? In addition, a great effort has to be done Studying the tools used in this methodology and to examine whether or not there are specific tools to be developed, especially in construction industry, were there are some tools more efficient than others are.

We also need to study the possibility of developing a model for collecting and analyzing information to detect patterns and forecast any changes. Can we develop tools for evaluating solutions and ideas generated by design thinking? Is Design Thinking successful in specific type of problems, and which type is it? All these questions may represent topics for further research concerning using Design Thinking in Construction Management.

6.4.2 On Professional Level

Nowadays, many universities around the world are introducing Design Thinking training in the Executive Education Programs. A training workshops need to be developed for professionals as well as construction managers who need to develop their design skills to be able to adapt Design Thinking within their work environment. These workshops need to address different disciplines within the construction industry, management, design, and execution. More over the administration teams need to be on the same mind set, since we need to benefit from the ideas coming from multi-disciplinary teams.

6.4.3 On Educational Level

Graduate and undergraduate students need to study Design Thinking within their curriculum; it will help them develop their skills within the academic environment, which will definitely affect their practical life. In some universities, Design Thinking is being taught in Business schools, while in others, it is taught in Design schools; therefore, it can be a cross-disciplinary course, with good coordination between different schools, where a great number of student can benefit.

Design Thinking can give the construction industry a new point of view for problem solving. As a very dynamic industry, construction adapts sophisticated systems for management like resources management, time management, risk management..etc, However , by applying Design Thinking to these systems we can achieve radical breaks and innovation.

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