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IMPROVISATION IN CONSTRUCTION - TYPES, CHARACTERISTICS AND INFLUENCING FACTORS

by

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AN ABSTRACT OF THE THESIS OF

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Improvisation is defined as intentional but extemporaneous, rational decision-making. It is a helpful skill of decision making under time pressure and without the optimal information and resource. Even though managers tried to eradicate improvisation from their organizations it continued to exist as a complementary process for planning. In construction industry, improvisation is acknowledged as a fact of life, but there exists no clear understanding of this process and the factors influencing it. The purpose of this study is to provide a better understanding for improvisation in construction, realize the factors contributing in sound improvisation and finally model the process of improvisation in construction to guide the specialists' decisions-making process towards attaining the desired improvisational outcomes. In order to accomplish that, an ABC model was developed to group all antecedents, behaviors and consequences of improvisation; and fatherly a survey was conducted to gather necessary data in order to analyze the developed model. The data analysis showed that experience and the type of organization have a significant effect on the outcomes of improvisation in construction. In addition, the performed data analysis helped the authorrecognize the most frequent causes, methods and types of uncertainties faced while improvising. This analysis further identified the methods and type of training which are considered effective, as well as the personal and organizational characteristics that would help enhance the practice of improvisation. Nevertheless, the data analysis pinpointed the frequent procedures practiced while making the improvised decision.

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CHAPTER 1

INTRODUCTION

Henry Fayol summarizes management practices as planning, organizing, leadership, coordination and control (Alipour et al., 2013). The business dictionary defines planning as the act of devising plans to achieve optimal balance between goals and available resources; that is accomplished by first identifying goals, designing strategies to achieve them, choosing a suitable course of action and the methods associated with it and finally implementing and controlling the process. Organizations have always emphasized the importance of planning for managing uncertainties, increasing efficiency, reducing risk, organizing work, facilitating communication, supporting fruitful decision making, maintaining good control and reaching required objectives (Akrani, 2014).

However, a lot of the organizational actions can have unintended or unexpected consequences according to the chaos theory (Cunha et al, 1999). Woods and Hollnagel (2006) indicated that organizations cannot develop plans and procedures for all possible eventualities. Furthermore, Ryle (1979) confirmed that most of the occurring incidents are unprecedented, unpredictable and never to be repeated. In order to cope with such dynamic environments and adapt to these unanticipated events, improvisation may appear as the final resort for fighting these high levels of uncertainty, complexity and dynamism (Trotter et al. 2012).

Improvisation as defined by Ciborra (1999) is “intentional but extemporaneous, rational decision-making”. It is a helpful skill of decision making

under time pressure and without the optimal information and resources (Ciborra, 1999).In order to keep abreast with competitors, organizations need to increase the speed and capacity of their respond to emergent situations (D'Aveni, 1994), thus improving their improvisational skills.

It is commonly known that the levels of uncertainties are considerably high in construction. While studying uncertainties in various types of organizations, Lawrence (1981) assigned the highest level of information uncertainty to construction. Lean production system inserted new concepts into planning to increase its efficiency in fighting variability and delivering required value to the customer within the optimum conditions (Hamzeh, 2009). The Last planner system was devised to mitigate foreseen uncertainties and manage them. It emphasizes gradual removal of constraints by planning in greater detail as we approach execution (Hamzeh, 2009). But a complex environment necessitates improvisation as a complementary process for planning since ithas the potential to help organization subdue unplanned incidents into their own good will and protect themselves, at least partially, from unavoidable situations (Cunha et al, 1999).

While improvisation in jazz has been thoroughly explained in a theory that musicians can practice, no such theory is present for improvisation in construction industry. Researches such as Moorman and Miner (1998) and Chelariu et al. (2002) provided a clear typology for organizational improvisation and its influencing factors. Furthermore, cognitive models describing improvisation processes are only available for jazz. But regarding construction, very few researchers have tackled the subject.

The purpose of this study is to provide a better understanding for improvisation in construction, realize the factors contributing in sound improvisation and finally model the process of improvisation in construction to guide the specialists' decisions-making process towards attaining the desired improvisational outcomes.

CHAPTER 2

BACKGROUND

2.1. Defining Improvisation

2.1.1. General Definitions

The word improvise is rooted from the word “proviso” which embodies performing plans. Hence improvisation stands for the opposite of executing plans, it stands for reacting to the unexpected or unforeseen (Weick, 1998). A variety of scholars focused on different criteria while defining improvisation. Some authors concentrated on the methods used to improvise. For instant, Ciborra (1999) defined improvisation as the act of producing new combinations of resources, routines, and structures in order to cope with the present wicked situations. Other researchers focused on the temporal distance between conception or planning, and execution. For example Kamoche and Cunha (1997) defined improvisation as: “the merging of composition and performance, where both happen contemporaneously”. A third group of scholars emphasized on the spontaneity aspect of improvisation and how it happens at the spur of the moment; a good example of that is Mayer’s (1998) definition that states improvisation as generating resourceful solution to emergent problems in the nick of time. Furthermore, another aspect highlighted in previous researches is the innovations present in improvisational incidents. Many definition included terms such as innovation, creative, intuition, imagination and invention. The table below shows

the developed classification for different definitions according to the criteria previously described.

Table 1-Classification for different definitions

The definition Emphasized on:	Definitions	Authors
Method Used	"Efficiently generate new combinations of resources, routines, and structures which are able to match the present, turbulent circumstances".	(Ciborra, 1999)
	"Improvisation involves combining known and unknown routines in different contexts"	(Leybourne, 2006)
	"The pitting of an acquired competence or skill against un-programmed opportunity, obstacle or hazard"	(Ryle, 1979)
Time aspect	"The merging of composition and performance, where both happen contemporaneously"	(Kamoche and Cunha, 1997)
	"Composition converging with execution"	(Moorman and Miner, 1998a)
	"Created in real time emergent synergy"	(Pasmore, 1998)
	"Formulating and implementing strategies together in real time"	(Perry, 1991)
	"Thinking both compositionally and spur of the moment at the same time"	(Weick, 1999)
Spontaneity aspect	"In the nick of time devising resourceful solutions to intractable problems"	(Mayer, 1998)
	"Extemporaneous and deliberate organizational action"	(Cunha et al., 1999)
	"Intentional but extemporaneous, rational decision-making"	(Ciborra, 1999)
Innovation	"The invention, adoption and implementation of new ideas by individuals within the context of shared awareness of the group performance as it unfolds over time"	(Bastein and Hostager, 1988)
	"Making decisions and adapting to changing needs and condition. Ideas emerge in new and creative ways not planned by the performer".	(Crossan et al, 1996)
	"Organizing in a way such that the actors both adaptively innovate and efficiently execute."	(Eisenhardt, 1997)
	"To use the structure in creative ways that enable altering the structural foundation of performance"	(Hatch, 1999)
	"Intuition guiding action upon something in a spontaneous but historically contextual way	(Hatch, 1997)
	"Enacting an ongoing series of local innovations that embellish structure, respond to spontaneous departures and unexpected opportunities, and iterate or build on each other over time"	(Orlikowski and Hoffman, 1997)
	"Disciplined imagination"	(Weick, 1999)
	"When one organizational order collapses, and a substitute is invented immediately"	(Weick, 1993)
	"Mind in action"	(Scribner, 1986)
	"Creative and spontaneous behavior of managing an unexpected event"	(Magni et al, 2009)
	"Immediate and spontaneous process of creation"	(Sharron, 1983)

Early definitions for improvisation were inspired by the jazz theory. Mark Levigne (1995) defined the theory of jazz as the attempt to figure out rules that explain how great musicians played the way they did. He also added that while 99% of playing a great solo can be referred to things that are explainable, analyzable, categorizable and doable; only 1% can be referred to magic. However, experienced musicians have learned and practiced this 99% to an extent that they no longer have to think about it anymore. Thus in order for a musician to reach this magical 1% and go beyond the theory, he has to practice the 99% and learn them.

A classification of definitions for improvisation was presented by Cunha et al. (1999). They differentiated between two types of researchers studying improvisation. First type was referred to researchers who derived their definitions from the jazz theory without addressing its limitations in organizational arena; and second generation researchers who studied improvisation through empirical examples of improvisation in organizational settings.

Depending on a detailed study of various definitions for improvisation, Cunha et al. (1999) concluded a general definition for organizational improvisation.Their definition explains improvisation as "The conception of action as it unfolds, by an organization and/or one of its members drawing on available material, cognitive, affective and social resources". They distinguished in their definition four different types of resources: material, congestive, affective and social resources. Material resources include all resources outside social systems and individuals. Cognitive resources consist of all expertise and learning earned by an

individual while working inside or outside the organization. Affective resources incorporate the emotional state of the improviser. Since adequate emotional states can help in avoiding group deviations, it has been considered as a necessary condition for improvisation to happen(Cunha et al., 1999). And finally social resources take account of formal and informal networks of communication between employees (Cunha et al., 1999).

Cunha et al. (1999) used the term organizational improvisation which associates improvisation to organizations. They further explained that for a variation from plans to be identified this implies the existence of a social or congenital structure. A minimal structure was considered as a necessary condition for improvisation (Cunha et al., 1999).

2.1.2. Bricolage

Bricolage is defined as producing with whatever available materials (Weick, 1999). Several authors use the terms improvisation and bricolage interchangeably. Cunha et al. (1999) confirm that planners practice bricolage in order to improvise. Since time pressures the planners to resolve the situation, they can't wait for the optimal resources to be available. The planners need to use whatever available resources to plan and execute simultaneously (Cunha et al., 1999).

Furthermore, Cunha (2005) considered that bricolage may go beyond resolving situations with whatever available resources to inventing new resources from available but not optimal ones. This act is also referred to as "resourcing" when

a new combination of available resources is presented or when the same resources are used differently in a creative way in order to fit the demands of the emerging situations (Cunha, 2005).

Verjans (2005) compared the literal definitions of improvisation and bricolage. Since bricolage is the French translation of tinkering, he considered bricolage as the ineffective damage repair with good intentions. On the contrary he associated improvisation with extempore creation or construction (Verjans, 2005).

On the other hand, Trotter et al. (2013) differentiated between improvisation and bricolage; they considered bricolage as an adaptation process while improvisation as a process relying on creative and innovative methods and tools.They further indicated that bricolage may occur in pre-planned situations to reduce cost or compress project duration, thus bricolage can happen outside of improvisation which is specific to emergent non planned situations(Trotter et al., 2013).

In this study, bricolage is considered to be a particular case of improvisation and not a synonym to it. An example for a case of improvisation where bricolage is not applied is when the planner finds another method to obtain all optimal resources for executing the task rather than recombining the currently available ones.

2.1.3. Improvisation in Jazz

Many scholars use improvisation is jazz as a metaphor and reference of knowledge when studying improvisations in organizations. Improvisation in jazz is considered as a serial process that involves “conceiving, interpreting, articulating, and

remembering an unwritten evolving score" (Berliner, 1994). It is stated as a serial process since steps performed toward the goal cannot be undone. These steps are planned and executed simultaneously to respond to the unfolding events; they form the incremental changes toward the goal of jazz improvisation and thus these actions are irreversible (Mendonca & Al Wallace, 2007; Weick, 1998).

Mendonca & Al Wallace (2007) further defined the term "referent-based" improvisation where improvisers build their creations on a given referent or theme. Weick (1998) highlights the fact that such referents have a great influence on the improvisers thinking and resulting actions. Three types of referent based improvisation were stated: paraphrase, formulaic and motivic improvisation. While in paraphrase improvisation the improviser inserts notes that are similar to the given theme, in formulaic improvisation the improviser inserts his favorite tune into the given referent theme. Motivic improvisation was considered the most challenging one since it involves the introduction of deeper changes into the given referent or plan and consequently building on these modifications (Mendonca & Al Wallace, 2007). Evidence has showed that referents help improvisers widen their musical ideas. Improvisers tend to recall existing motifs, modify these according to the theme played and finally playing them (Mendonca & Al Wallace, 2007).

When improvising in jazz, the player analyzes the notes being played while quickly recalling similar past events and exploring opportunities for new outgrowths. He also has to examine the future implications for such actions before performing them. Thus he has to jungle between short, intermediate and long range goals. Where

the first is playing the notes, the second is analyzing opportunities to improvise and the third is exploring the future influences of such improvised actions Berliner (1994).

2.2. The Need for Improvisation

Organizational theory gives much importance to control and order. Hence managers have always preferred planning and resourcing where they can rely on routine, repetition and automatic processing (Weick. 1998). Traditionally, their emphasis on planning and control has prevented them from acknowledging the role of creativity and innovation. Thus, they considered improvisation as the deviation from the plans and as a potential source of risk and thus something that should be avoided and controlled (Hollnagel 2006).This might have restricted the role of improvisation in resolving problems and helping organizations co-evolve with their environments (Cunha, 2005).

While in repetitive and stable situations plans, contingency plans and traditional resource management methods are applicable, in complex and dynamic environment the role of improvisation increases. Improvisation may be employed to 1) help resolve emergent problems,2) cope with discontinuity, multiple commitments, interruptions and dynamics environment and 3) compensate for bad management and human errors (Cunha, 2005;Mendoca & Wallace, 2007; Chelariu et al., 2002).Even though there was an approach to eradicate improvisation from business organization, improvisation continued to exist in many emergent situations (Ciborra,1999). This led to a new approach that considers improvisation as a complementary part for planning rather than considering it as an undesired fluctuation in plans (Ciborra, 1999). In order

to keep abreast with competitors, organizations need to increase the speed and capacity of their respond to emergent situations (D'Aveni, 1994), thus improving their improvisational skills.

The importance of improvisation in organization management has repeatedly been manifested in the literature. In fast-changing environments, improvisation was considered as the most robust practice for surviving and succeeding (Brown and Eisenhardt, 1997). Mendoca & Wallace (2007) further stated that the ability to improvise and flexibility are considered crucial for obtaining optimal results in emergency settings. They also declared that encouraging employees to practice improvisation can enhance quality management. Another study that marked the role of improvisation is that performed by Leybourne (2006) in which only one out of 100 interview respondents did not support the use of improvisation in organizations. Furthermore, Daft and Weick (1984) asserted that managers resort to improvisation to seek information in dynamic environments. Chelariu et al. (2002) extended beyond that to describe planning in complex environments as perilous since it can lead to future complications. They also implied that such complications would require improvisational efforts to resolve them.

2.3. Characteristics of improvisation

2.3.1. Degrees of improvisation

In most of the literature, the degrees of improvisation are framed as a continuum rather than using discrete categories with vague boundaries to enclose them. Cunha et al. (1999) utilized such a continuum that starts by interpretation,

embellishment followed by variation and at the upper limit improvisation. Interpretation refers to the setting where plans are strictly followed, while in embellishment small variations are introduced into the original plans that remain recognizable. On the other hand, in variation new procedures are introduced into the plan and finally improvisation refers to radical departure from the original plan. Hence actions that alter, revise, create, and discover are more improvisational than those that shift, switch, or add (Weick, 1998). This continuum was also used by Trotter et al. (2012) where they used it to describe levels of novelty as a characteristic for improvisation.

Novelty and the degrees of improvisation are similar constructs used interchangeably in literature. As defined by Chelariu et al. (2002) novelty of improvisation is the extent to which improvisation diverge from the original plans. Based on their research they proposed that the novelty of improvisation increase depending on four factors. First as the forms for sharing information are more intensive and evolved, the novelty of improvisation will probably increase. Similarly, as information is more widely shared and the uncertainty of the environment augments, the novelty of improvisation is expected to be higher. On the other hand, as information interpretation becomes more common the novelty of improvisation is anticipated to decrease (Chelariu et al., 2002). None the less, Ryle (1979) suggests that as the novelty of the emergent situation increases, the novelty of improvisation should proportionally increase otherwise this improvisation is not the suitable response for this setting.

While in the previous approach only radical departure from plans was considered as improvisation, researchers tackling this subject in both organizational and musical settings argue that improvisation occurs through incremental steps of small variations or other lower degrees of improvisation. This approach resembles the butterfly effect mentioned in the chaos theory (Cunha et al. 1999). Thus considering improvisation exclusively as a punctuated event may be misleading.

Moreover, novelty is considered as a necessary condition for an action to be stated as improvisational in jazz settings. While in organizations, a repetitive ad hoc response to an unplanned response to an emergent unplanned situation is declared as improvisational (Berliner, 1994). Weick (1998) further added that as improvisational actions are more novel, they are more influenced by past experience, dispositions, and local conditions. Hence as time is more pressured, individuals tend toward interpretation and embellishments more.

2.3.2. Speed

Time pressure and improvisation were often mentioned simultaneously in the literature. Speed was considered as a main characteristic for improvisation around which many propositions were formed. Chelariu et al. (2002) stated that as the information is shared with a wider group of individuals, the improvisation is expected to be of low speed and associated with more powerful forms of information generation. They also proposed that as individuals share common information interpretation the improvisation will probably be a fast one. In addition they claimed

that high speed improvisation will result in better outcomes in a dynamic environment since it can cope with the fast changing circumstances.

2.3.3. Additional characteristics

In addition to speed and novelty, internal coherence, external coherence (outcomes) and learning were also considered as characteristics for improvisation. While internal coherence refers to the common agreement between the team members around the improvised action, external coherence represents how much improvisation responds successfully to the emergent situation (Chelariu et al., 2002). Chelariu et al. (2002) further stated that the relationship between internal coherence and information flow is non-linear. Although at first as information flow increases the level of internal coherence increases as well, it reaches a point where excessive information can cause confusion and thus overburden improvisers. Noting that with advanced technology the problem is no more related to acquiring information but to finding a method to process and assimilate the new information. In order for members to improve the level of internal coherence they need to agree on a sufficient number of measures to evaluate the different suggested approaches.

On the other hand, improvisation was repeatedly correlated with organizational learning through literature. Moreover, improvisation was defined as circular process of learning progressing through discovery, retention, and exploitation of stored knowledge and insertion of learned lessons into the organizational memory. Improvisers continuously evaluate the results if the actions and build upon them, thus learning as they improvise. This learning can either be consistent with the

organizational culture and hence called adaptive or reflecting ideas outside the usual procedures known to the organization and then called generic (Huber, 1991; Chelariu et al., 2002).

Moreover, the possible outcomes of improvisation were considered to characterize it as well. J.V Cunha & M.P Cunha, (2010) distinguished between improvisation leading to change in procedures and resilient improvisation leading to reproduction of work plans. Their work focused on identifying the boundaries between improvised change and improvised stability. In order to accomplish that they defined 3 processes: variation, selection and retention. All three can lead to improvisation of new mental models and resources that people can draw upon in the future or discard.

2.4. Influencing factors

Scholars in general focused on the influence of work environment on improvisation. For instant, Chelariu et al. (2002) suggested some methods that could help managers facilitate improvisation. First managers should identify the types of uncertainties dominant in their work environment. In their study 3 types of environments were distinguished: 1) rapidly changing environments where the rate of change is high, 2) uncertain environments where the changes are complex and 3) equivocal environments where high complexity leads to vague definition of goals. Furthermore, they advised mangers to encourage their employees to improvise and overcome the fear of failure. Afterwards the development of performance criteria was recommended to judge improvisational outcomes. And finally they emphasized the

importance of storing improvisational experience in the organizational memory for future reference and development.

Trotter et al. (2012) explored a wider range of influencing factors that can affect the way members improvise in an organization. 1) Experience with all its different aspects starting by the ability to recognize an undesired situation, the ability to identify and use leverage points and finally the ability to generate alternatives. 2) Training where Klein (2007) suggested that when individuals have a large range of routines and actions to draw on, could improve their improvisational abilities. Thus training that target improving the response options available for workers would result in better improvisational skills. Trotter et al. (2012) additionally stated that training can improve the workers' ability to mentally simulate the results of his action and hence his ability to practice fruitful improvisation. 3) Education that allows employees to learn the high-level concepts of their field and the core values of their organizational culture. 4) Situation awareness or the ability to accurately evaluate the current setting. 5) Team work since as trust and collaboration grows between the employees their improvisational capabilities grow especially as they earn more experience (Vera and Crossan, 2005). 6) Information flow that allows immediate feedback of improvisational outcomes thus enabling the improviser to build on or correct the course of his actions. 7) Minimal structures or organization role system since the lack of role definition can cause confusion in emergency settings. 8) Organizational memory whereas employees rely on a wider database of past experience and learning they become able to practice better improvisation (Mendonca & Wallace, 2007). 9) Organizational culture, especially the way managers track error

and deal with blame. A learning and experimental culture that empowers employees would be more capable of successful improvisation (Vera and Crossan, 2005). 10) Authority mitigation and role switching to members with higher expertise and allowing them to go beyond standard operating procedures.

On the other hand, Weick (1998) suggested some group practices that would enable improvisation. He considered that an organizational culture that is willing to pass by planning and formal documents in the favor of fast action would provide a suitable environment for improvisation. In order to do so, the employees should have full understanding of the available resources and their uses in addition to well coordination between each other. Furthermore, employees are advised to pay attention to the work of their colleagues in order to recognize chances for improvisation. Such organization should further rely on experienced employees, rich organizational memory and trusted partners who share a similar culture.

Furthermore, Leybourne (2006) advised four main characteristics of an environment that would support improvisation. First he emphasized the importance of relaxation of controls along with building trust and commitment between employees. He additionally recommended organizations to acquire tolerance for non-optimal solutions in order to enrich their learning process. He finally stated that an "emergent best practice" should be continuously developed in order to cultivate continuous improvement. This approach resembles Kaizen principle in lean practice. However, improvisation influencing factors have never been considered as a topic for research in the construction field thus this research aims to fill that gap.

2.5. Types of improvisation

Providing a categorization for the different improvisational incidents would help us better understand the process by providing a clear ontology that sorts such occurrences. One typology was provided by Moorman and Miner (1998) where they identified three criteria to classify improvisation. First improvisation was classified into collective vs. individual improvisation depending on how many individuals are involved. Second improvisation was classified into product improvisation if it improvises on the outcome or product, and process improvisation if it improvises through inserting new methods and procedures. Finally the third criteria differentiate between behavioral improvisation where new actions are performed to resolve the situation and cognitive improvisation that refers to the insertion of new interpretations or ideas to respond to the current issue (Cunha et al. 1999).

Another typology was suggested by Chelariu et al. (2002) who differentiated between four families of improvisation: familiar, different, swift, and capable. The four families differ in the levels of speed and novelty. They assigned low speed and low novelty to familiar improvisation and believed that it would be more common in equivocal environments. As for slow but novel improvisation, they considered it as different improvisation occurring in uncertain but learning environments. On the contrary, fast improvisation with low level of novelty was stated as swift improvisation. And finally capable improvisation was characterized by high speed and novelty level special for experienced and learning environments. In such environment as the members become more experienced they overcome the trade-offs

between speed and novelty thus attaining capable improvisation (Chelariu et al., 2002).

Few scholars aimed to provide a clear typology for organizational improvisation and even the ones mentioned above seem to require additional development in order to serve their role. Cunha (1999) further stated that only through empirical grounded research a useful typology can be built. This research aims to fill that gap particularly in the construction field.

2.6. Improvisation in construction

Improvisation has traditionally been considered as an undesired deviation from plans and procedures and thus as something that should be avoided and controlled. This may have led to the fact that few researchers have considered this subject in the construction field. The only attempt to study improvisation in construction was performed by Hamzeh et al. (2012) where the purpose of their research was to evaluate the performance of look-ahead planning and the complementary role of improvisation identifying when, how much and where it is utilized. In order to do that Hamzeh et al. (2012) conducted interviews with construction specialists with different roles on three construction projects. They noticed that the organization culture may prevent blue collar employees from creating new procedures even when the plans fail to serve the emergent situation. This may also expand to the managerial level in some organizations. As a result of their work they recommended the following: first teams should practice collaborative planning by engaging more people to create reasonable plans that can be executed on time.

These plans should always be updated and reviewed to match the dynamic environment of construction industry. On the other hand, unforeseen uncertainties can lead to emergent problems that hinder the execution of plans. In such cases, employees are advised to resort to improvisation which may serve to adapt the standard operating procedures or create ones that are more suitable for such complex and dynamic environment.

Moreover, Hamzeh et al. (2012) grouped failures in executing tasks into three categories. The first group involves failures in executing planned tasks the thing that may be referred to deficiencies in identifying constraints and removing them. The second group stands for failures due to lack of planning and such failures may be caused by inappropriate definition of scope of work. As for the third groups it includes failures caused by uncertainties that cannot be foreseen. Managers should aim to improve planning in order to eliminate the first two groups of failures. But to deal with the third unavoidable group, planners are advised to improve their improvisational skills to help them cope with these failures and overcome them (Hamzeh at al., 2012).

While Hamzeh et al. (2012) proposed improvisation as a solution for emergent situations; several other scholars addressed making-do in order to execute tasks which their complete kit is unavailable. Making –do refers to the situation where a task is launched or continued without all its prerequisites ready (Kosekela, 2004). The inputs for a task are considered not complete due to unavailability of resources or the availability of non-optimal or non-standard resources. Ronen (1992) and

Kosekela (2004) identified the following reasons for starting an activity with an incomplete kit (i.e. without all its inputs):

- Maintaining high utilization rate
- Avoiding schedule slippage
- Efficiency syndrome(following the believe that worker should be busy all the time)
- Pressure for an immediate response (pressure applied by customers or managers)
- Push type of planning causes input unavailability
- Improper workload distribution
- Inadequate definition of scope of work
- Anxiety to show goodwill on the part of workers and foreman
- Inadequate procurement of material (misleading lead time information)
- Thermostat reactive model

Although improvisation and making-do may share similar causes, improvisation is spontaneous rational planning to overcome such incomplete kits with no or least amount of waste possible. Moreover, improvisation may extend beyond responding to incomplete kits into improving the usage of a complete one. Rather accepting the incomplete kit, employees may resort to improvisation to overcome such situations and avoid make-do waste.

In order to improve the implementation of improvisation in the construction field, organizations need to acquire a better understanding of the process. This study

aims to clarify the different types of improvisation occurring in the construction field. This research aims to further identify the factors characterizing and influencing improvisation in construction industry. And by studying all these factors, some practices that would help improvisers attain the desired outcomes can be advised.

CHAPTER 3

PROBLEM STATEMENT AND SIGNIFICANCE

Organizations have always relied on planning in order to fight variability and uncertainty. Nevertheless, as it has been manifested earlier, unforeseen uncertainties and emergent unintended consequences of humans' actions could not be eradicated from business organizations. In addition, Woods and Hollnagel (2006) confirmed that we cannot develop plans and procedures for all possible eventualities. In order to respond for such emerging situations employees have repeatedly resorted to improvisation in order to perform work and acquire the desired outcomes.

Although traditionally improvisation was considered as a fluctuation of plans that needs to be removed in order to optimize the process, it continued to exist in various types of business organizations (Ciborra, 1999). This led to a new approach that considers improvisation as a complementary part to planning that needs to be studied and improved. Improvisation is stated as immediate rational planning to meet sudden difficulties in executing plans (Ciborra, 1999). Particularly in the construction field, Hamzeh et al. (2012) evaluated the performance of look-ahead planning and the complementary role of improvisation. As a result, they classified failures in executing plans into three categories. While the first two are caused by inadequate definition of the scope of work or failures in the look-ahead planning (i.e. failure to identify and remove constraints); the third is referred to unforeseen uncertainties that can only be resolved through improvisation.

Since the levels of uncertainties are considerably high in construction field, thus there is an urgent need for improvisation. However, very few researchers have tackled the subject. In order for us to better understand improvisation, it is important to study the various types of improvisation present, what characterizes each and identify the influencing factors and possible causes and outcomes. The purpose of this study is to provide a better understanding for improvisation in construction, realize the factors contributing to sound improvisation (i.e.: improvisation which performs the required task with the least amount of emergent waste) and model the process of improvisation in construction to guide the engineer's decisions-making process towards attaining the desired improvisational outcomes.

CHAPTER 4

PROPOSED SCOPE OF WORK

The goal of the proposed study is to understand improvisation present in the construction field. This research aims to do that by identifying the different types of improvisation present, and by providing credible examination of causes, characteristics and influencing factors. The different influencing factors will be analyzed and recommendations for improvement will be developed. Below are the specific objectives of the proposed research study:

- *Examine and understand the actual improvisation practice present in the construction field*. This includes identifying the types, causes, characteristics and influencing factors.
- *Modeling the process of improvising.* This includes identifying the stimulants, behaviors and consequences of improvisation in construction. This also includes identifying the steps an improviser would implement in order to improvise.
- *Analyze how the different factors affect the results of improvisation.* After modeling all the causes and influencing factors of improvisation, it is important to examine how much influence these factors and causes have on the outcomes of improvisation. Through examining which of these factors affect the outcomes of improvisation, a set of practices that can contribute to sound improvisation can be advised.

CHAPTER 5

METHODOLOGY

To achieve the research specific objectives the following procedure was implemented:

1. *Conduct a literature review on improvisation in organizations to aggregate the different types and factors that could be related to construction field.* The review investigated the different types of improvisation present. It aggregated the different possible causes, characteristics and the different factors affecting improvisation.
2. *Based on the conducted review, propose an ABC model that groups all possible causes, influencing factors and outcomes of improvisation.* The proposed ABC model will further include a flow chart that models all possible steps in the decision-making process an improviser practices. The decision-making flow chart presents all the different possible actions and thoughts an improviser experiences while improvising.
3. *Develop a survey to collect data about the main causes, characteristics and influencing factors of improvisation.*
4. *Document the dominant influencing factors of improvisation by conducting the survey.* This step consists of filling surveys by interviewing different engineers and blue collar foremen to document their experience with improvisation.

5. *Analyze and refine the collected data*. The data and information collected from surveys and interviews will be combined and refined to analyze them and draw conclusions on the light of the results. Statistical analysis will be done if necessary and any outlier will be removed to avoid errors in the study.
6. *Conclude which characteristics contribute to sound improvisation.* After analyzing the collected data of the survey, factors that contribute to sound improvisation are identified.

5.1. The proposed ABC model

In order to model the process of improvisation in construction, an ABC model that sums up the antecedents or stimulants, behaviors and consequences of improvisation was developed. The figure below presents the developed ABC model:

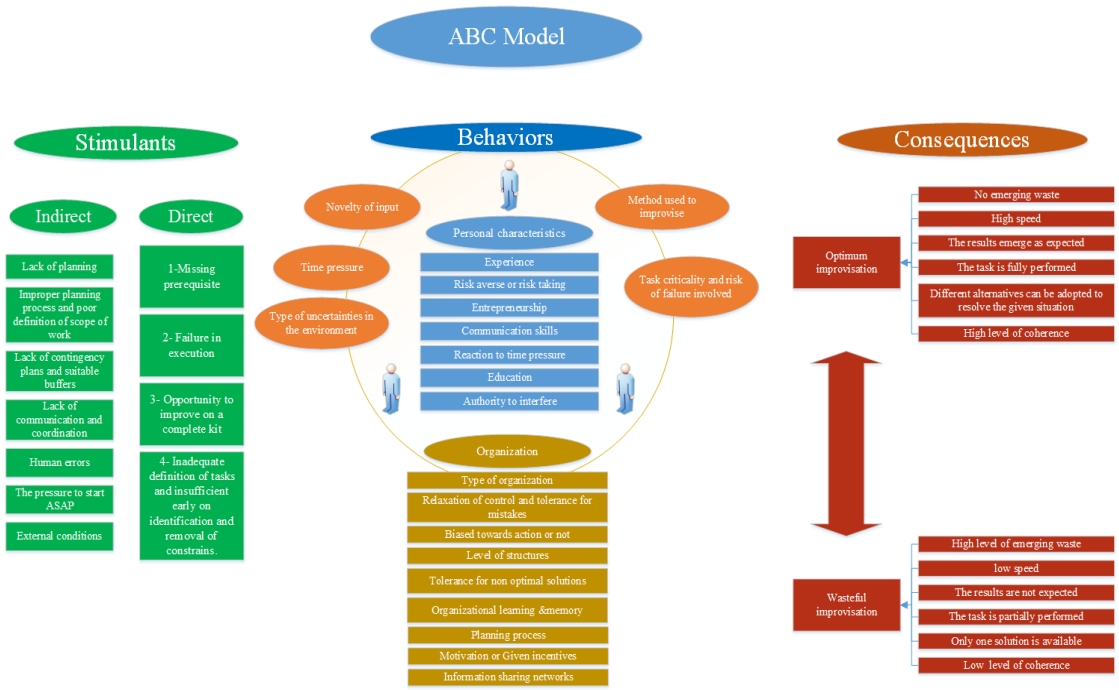

Figure 1- The developed ABC model

5.1.1. Stimulants of improvisation

The figure below sums the stimulants for improvisation:

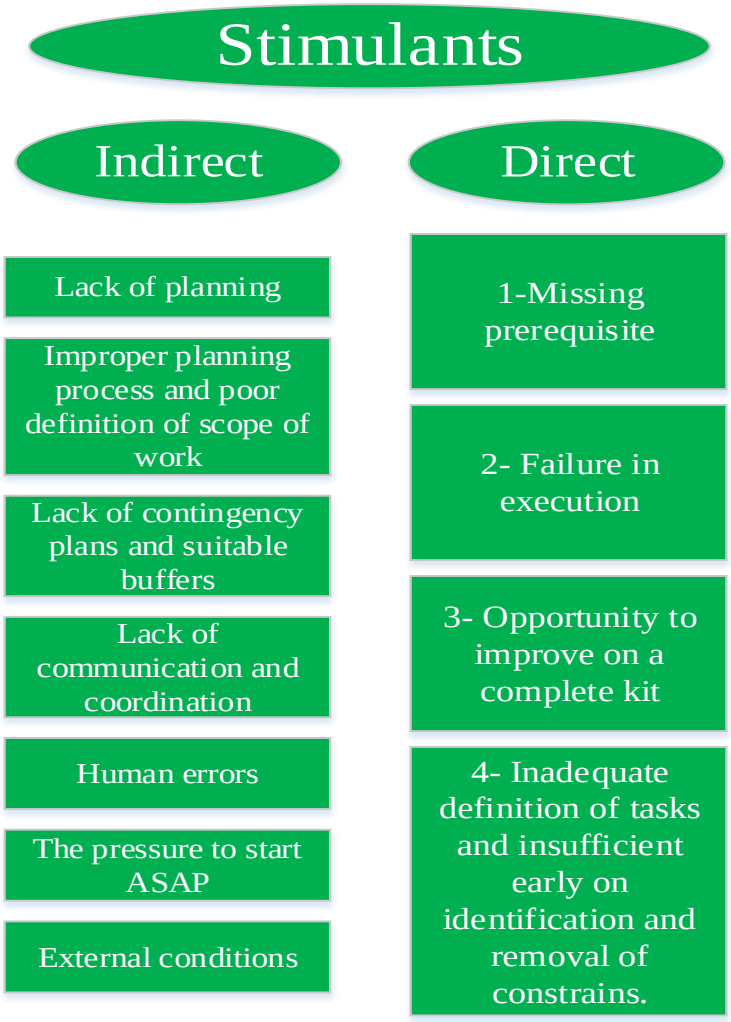

Figure 2-Stimulants of Improvisation

Improvisation can be stimulated by different grounds. It may be needed either to initiate the execution of a certain task or to complete the execution of another. First, improvisation may be needed to initiate the execution of a task that is restricted by a missing prerequisite. In order to start, every task needs a complete kit

(Information, space, labor, temporary facilities, safe environment, equipment, tools, and previous work). Thus if any of its perquisite is missing improvisation is needed to resolve the situation and start the task. An incomplete kit can be referred to one or many of the following causes(Ronen, 1991):

Table 2-Missing Prerequisites

Missing prerequisites (incomplete kit)	Lack of information
	Variability in upstream tasks
	Crowded space or having no access to site
	Unskilled labor or lack of capacity
	Lack of temporary facilities and safety measures
	Lack of materials, tools or equipment
	External conditions (weather conditions)
	Allocation of resources and equipment doesn't match the task

Furthermore, improvisation may be needed to help complete the execution of a task that was hindered by a failure in execution. A failure in execution can be caused by poor definition of the scope of work, human errors or the emergence of new uncertainties. Some of the uncertainties faced may be avoided by preparing contingency plans or sizing suitable buffers that can absorb such variability. Thus failure in execution can be referred to poor definition of tasks, human errors or the lack of contingency plans and suitable buffers.

On the other hand, improvisation can be provoked by the appearance of new tasks or even new prerequisites that were not taken into account while planning. This can be referred to inadequate definition of tasks and insufficient early on identification and removal of constrains.

One more reason that stimulates the need for improvisation is the need to keep abreast with the competitors. Thus, improvisers would seek an opportunity to improve on a complete kit and hence start a task early on, shorten its duration or execute it with less resources and lower cost.

The causes mentioned above can be considered as the direct causes that stimulate the need to improvise. However, in the background of these direct causes lie other indirect causes such as:

1- Lack of planning
2- Improper planning process and poor definition of scope of work
3- Lack of communication and coordination
4- Lack of contingency plans and suitable buffers
5- Human errors
6- The pressure to start ASAP the can be imposed either by the client or the supervising manger. Such pressure can be the result of:
    i. Utilization syndrome (managers wanting to make sure all resources are utilized)
    ii. Lack of trust from customer pressuring the contractor to start ASAP
    iii. Contractors' faulted mentality to start ASAP
7- External conditions (For example: Weather conditions)

5.1.2. Behaviors

In order to model the behaviors of the improvisational process the author is going to discuss the different influencing factors. The figure below sums up the different influencing factors considered.

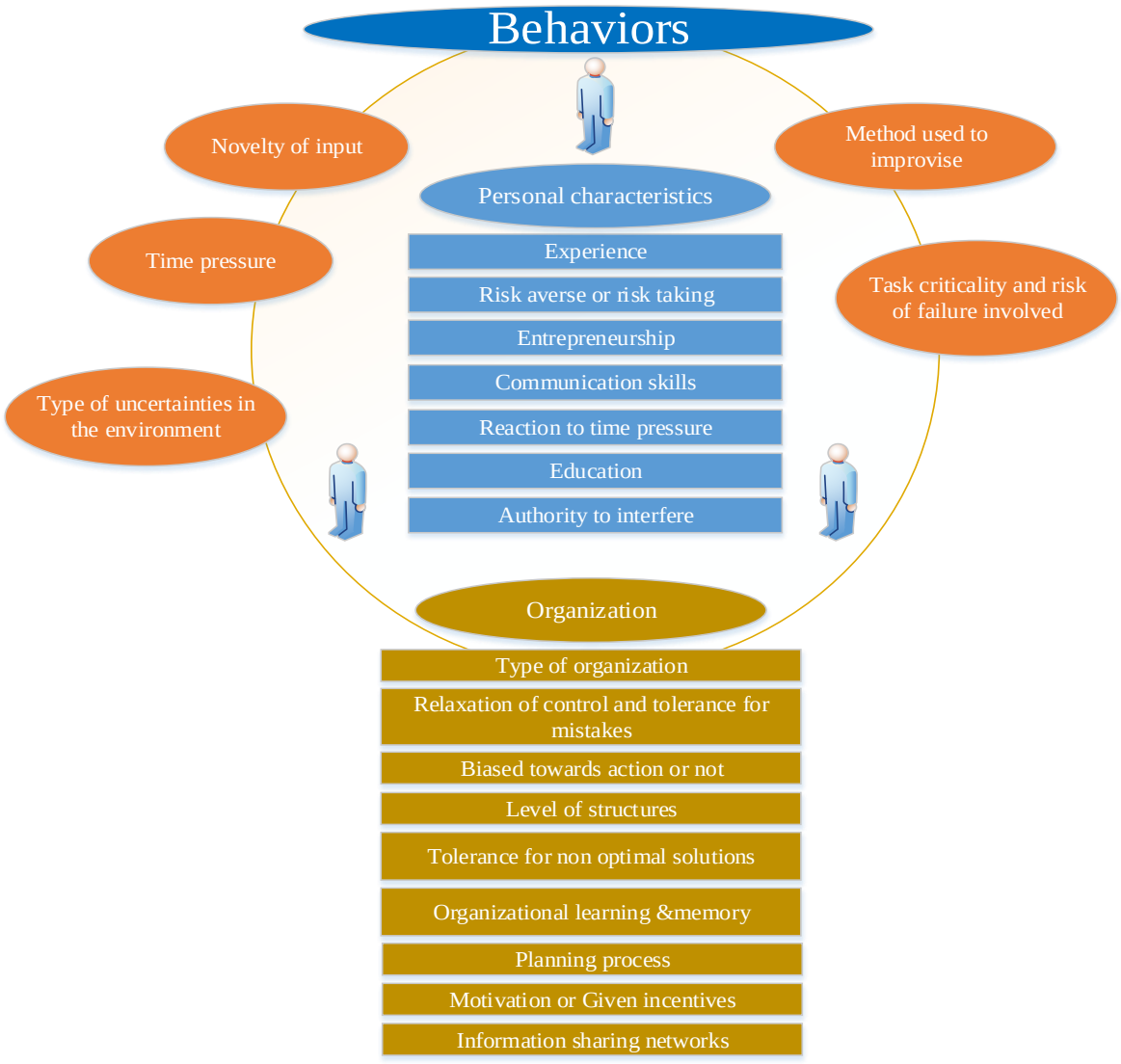

Figure 3-Behaviors section of the ABC model

Based on the thorough literature review performed, the author is able to aggregate different influencing factors that can affect the practice of improvisation in different types of organizations. However, no previous research has studied the influencing factors of improvisation in the construction field. The proposed ABC model in this study aims to describe the practice of improvisation in construction and it also proposes 3 groups of influencing factors that can affect the method used or the resulting outcomes. The first group includes the improviser's personal characteristics that can influence his improvisational practice. On the other hand, the second group of factors includes the characteristics of the organization that can influence the practice of improvisation. Finally, the third group includes the factors relevant to the specific task that requires improvisation.

5.1.2.1. First group: Improviser's personal characteristics

Faced by the same emerging uncertainty, two different people may react in a different way influenced by their educational background, experience, type of responsibility, etc… In this model the author tried to sum up all different personal characteristics that can influence the practice of improvisation and which are listed below.

1- *Experience:* As the individual gains more experience in a certain field, he gets acquainted to various types of uncertainties and emerging problems and thus learns methods to conquer them. Hence, his chances in successful future improvisation may augment. This proposition will be fatherly addressed in this research.

2- *Risk Averse or risk taking:* Some improvisational incidents may fail to complete the required task or they may result in a high level of waste beyond what is considered acceptable. While improvising one may be obliged to accept some risk of failure. Hence whether the improviser is risk taking or risk averse can affect his improvisational practice.

3- *Entrepreneurship:* Improvisation is stimulated by an emerging uncertainty that would require the initiative of an entrepreneur to resolve it. Thus entrepreneur is considered as an influencing factor.

4- *Communication skills:* Communication is considered as a crucial factor to identify the emerging uncertainty and thus acknowledge the need to improvise. In addition, it plays an important role in recognizing the method that best addresses the emergent situation and in getting feedback. Consequently, the communication skills of an improviser could affect his practice of improvisation.

5- *Reaction to time pressure:* Improvisation implies short temporal distance between planning and execution thus improvisation is most probably affected by the improviser's reaction to time pressure.

6- *Education:* Education affects the improviser's background of high level concepts. It also may affect the way he deals with risk, uncertainties and time pressure. Furthermore, the improviser's educational background can affect his behavior within his team and his communicational skills. Thus the improviser's education is considered as an important factor that might influence his practice of improvisation.

7- *Authority to interfere:* depending on the employee's post in the organization, he is given certain authorities to make decisions at a specified level of criticality and importance. Thus when faced by an emerging situation that he could improvise on he will always be restricted by these authority limits set for him.

5.1.2.2. Second group: Characteristics of the organization

Several characteristics of the organization might affect how the employee acts when faced by an emergency that requires improvisation. Some of these characteristics are mentioned below:

1- *Type of the organization:* McGILL & Slocum (1993) identified four different types of organizations: The knowing organization, the understanding organization, the thinking organization and the learning organization. The knowing organization focuses on standardized procedures and regulations where they discover something that works and commit to repeating it. In the knowing organization employees are not encouraged to rethink or improve the way things are done since they value efficiency above all (McGILL & Slocum, 1993). Furthermore McGILL & Slocum (1993) defined the understanding organization as the organization where the management practices aim to clarify and reinforce the core values derived from the company's culture. In such organizations they encourage employees to change within their divisions but these changes have to be consistent with the company's core values.

On the other hand the thinking organization specifies discrete set of solutions that are used to respond to any emergent problems (McGILL & Slocum, 1993). Reactive problem solving approach is practiced where the root causes are not addressed and analyzed. On the contrary, in a learning organization a proactive problem solving approach is practiced where root causes are analyzed and resolved. Moreover, in such organizations employees are informed about the company's performance and encouraged to experiment and implement changes. Failure in these organizations is accepted as an opportunity to learn and thus employees are persuaded to take risks and experiment with the process (McGILL & Slocum, 1993).

The type of organization sets the limits for experimenting, risk-taking, communication among the teams, and allowable change within the process. Thus the improvisation practice of an employee may be affected by the type of organization he works in. While working in a learning organization the employee is given the freedom to experiment with the process. In addition he is always informed about the progress of work and allowed to share information with his team and superior managers. Thus he may have a better chance of successful improvisation compared to another employee working in a knowing organization where he is not allowed to question the way the things are done or communicate information with other team members.

2- *Relaxation of control and tolerance for mistakes:* while improvising the improviser faces the risk of failure. If his work environment does not tolerate

mistakes or consider them as an opportunity to learn, he may hesitate before taking risk and improvising.

3- *Biased towards action or not:* an organization that is biased towards action is an organization that favors experimenting in order to discover what is the suitable course of action rather than only considering the suggested solutions theoretically. In these organization actions are a legitimate way to understand the situation. Among such organizations that are open to experimenting, there might be a higher chance to practice improvisation since employees are given the freedom to try and execute new ideas in order to test their effectiveness and better understand the situation.

4- *Level of structure:* an organization having the minimum level of structure would specify the role and duties for every employee. When every employee is certain of his responsibilities and liabilities, he knows when to interfere and understand what type of decisions he is allowed to make. Thus he knows the situations where he is responsible of improvising to resolve the emergent problem. Here it is worth mentioning that when authority mitigation is allowed within the organization it becomes easier for managers to pass down the responsibilities of making certain type of decisions to the employees performing the job. Hence giving more flexibility to the process of improvisation where the employee who is most familiar with the task is allowed to suggest the suitable improvised solution or even hold the responsibility of executing that decision.

5- *Tolerance for non-optimal solutions:* when faced by an emergent situation the improviser may have to accept some emergent waste in order to execute the task and keep the project on schedule. Some companies do not tolerate non optimal solutions, thus every improvisation must not lead to any emergent waste in addition to finishing the required task on time and from the first attempt to do so. This could restrict the practice of improvisation.

6- *Organizational learning and memory:* An organization learns when one or more of its members learn something that could be used in the future (Huber, 1991). Huber (1991) defined different types of learning starting from intentional and unintended experimental learning, acquiring second hand learning via observing others' experiments and learning by hiring new members who possess new knowledge. However, storing the learning acquired is important so it could be communicated, accessed, and utilized in the future. Information stored is referred to as organizational memory where learning is documented either on paper or in a computer-based network. While improvising the employee may refer to the learning documented in the organizational memory to help him make a more informed decision.

On the other hand, Mendonca & Al Wallace (2007) differentiated between declarative and procedural knowledge where declarative knowledge is knowledge of facts while procedural knowledge is knowledge of the methods used to execute the required task. Examples of cognitive models developed for improvisation in the emergency management field were stated in the literature and which are based on an anthology structured from the

declarative and procedural knowledge stored in the organizational memories (Mendonca & Al Wallace, 2007).

7- *Planning process:* managers have always emphasized the importance of planning for managing uncertainties and reaching the required objectives on time and within the desired budget and quality specifications. Hamzeh et al. (2012) suggested that managers should aim to improve planning in order to eliminate the failures in executing planned tasks and the failures due to lack of planning while only using improvisation to deal with the unavoidable uncertainties. Hence the amount and quality of planning done by the organization can affect how much improvisation is used in order to resolve failures.

8- *Motivation and given incentives:* when an employee practices successful improvisation and thus gets rewarded for his work, he would then get motivated to think creatively and improve the way he do things at work. Furthermore, when an employee is given the right incentives he might be urged to take initiatives and always try hard to resolve any emergent problems. Hence he would practice more successful improvisation.

9- *Information sharing networks:* while improvising the employee needs to get all the relevant information in the shortest and easiest way possible. According to his work environment, the information sharing networks differ and also the culture behind sharing information. Information can be shared via formal networks or informally via verbal communication. Verbal non formal communication plays an important role in understanding the current situation

and sharing feedback about the improvised decision to decide on the corrective course of action needed. Here 3 different cases can be distinguished: Information is shared and available on time, there exists delays in sharing information and finally if there is a lack of communication and information sharing.

5.1.2.3. Third group: Factors relevant to the specific task that requires improvisation

The remaining group of influencing factors that may affect the practice of improvisation includes the factors relevant to each specific incident requiring improvisation. These factors are examined below:

1- *Time pressure:* improvisation was defined depending on the close temporal distance between planning and execution as previously discussed. Thus the process of improvisation is frequently accompanied with time pressure. Time pressure differs with every incident requiring improvisation. If the need for improvisation is acknowledged right before the scheduled time to execute the task thus the time pressure is high. The time available to improvise is considered as an influential factor for improvisation.

2- *Novelty of input:* improvisation incidents might be of repetitive nature where the same problems frequently repeat themselves and thus the improvisers have more experience when improvising to resolve them. On the contrary, some incidents requiring improvisation are unique in nature and never happened to

any team member thus having high novelty of input the thing that might influence the improvisational process.

3- *Task criticality and the risk of failure involved*: a task is considered critical when its execution opens several other activities or when it is restricted by several time or resources constraints and must be executed on the scheduled time in order not to delay the project. When improvising on a critical task, the improviser has to consider the constraining resources. Hence it is considered as an influencing factor. On the other hand, the risk of failure accompanied with every improvisational incident is also considered as an influencing factor.

4- *Type and level of uncertainty:* Trotter et al. (2012) distinguished between 3 types of uncertainties in the work environment: the rapidly changing environment, the uncertain complex environment where the methods are not clear and the equivocal environment where the goals are not clear. Another type of uncertainties that can also be considered is when the need for improvisation is not clear and cannot be rapidly acknowledged. The type of uncertainty accompanied with each improvisational incident might affect the process of improvisation. Furthermore three cases can be differentiated: uncertain input improvisation for example: not being sure if the prerequisite will be available or not, uncertain methods where the required methods for reaching goals are not clear and uncertain output where the goals and objectives are not clear.

5- The method used to improvise:

The method used to improvise was modeled as a decision making flow chart. Mendonca & Al Wallace (2007) identified two stages in the decision making process when improvising. The first stage is identifying that there exists no previously planned procedure for the current situation at hand while the second state is development and implementation of new plans. Furthermore, the decision making process was also modeled by the Klein's RPD model starting by assessing the uniqueness of the situation and then mentally simulating different alternatives to reach a suitable solution. This is done through recognition and usage of leverage points in the situation that can be adapted into a novel solution (Klein, 1999).

In this model, the decision making process for improvisation is divided into six stages. As shown in the flow chart below, the process starts by scanning the need, then preparing for improvisation, followed by making the decision then gathering consensus around the improvised decision and finally executing and documenting the methods used and results obtained. After scanning the need to improvise, the improviser can either acknowledge the presence of an emergent situation and thus proceed in the process of improvisation; (Advance 1) or directly proceed to execution after making sure there is no need to improvise (Advance 2).

Furthermore, during execution the team could fail to execute the planned procedure due to an emergent failure of equipment for example. In such a case, the need to improvise appeared during execution and thus the improviser should

proceed from there to stage of preparation then making the decision followed by gathering consensus and finally completing the execution of the task. Each one of the six stages mentioned above is modeled as a number of steps.

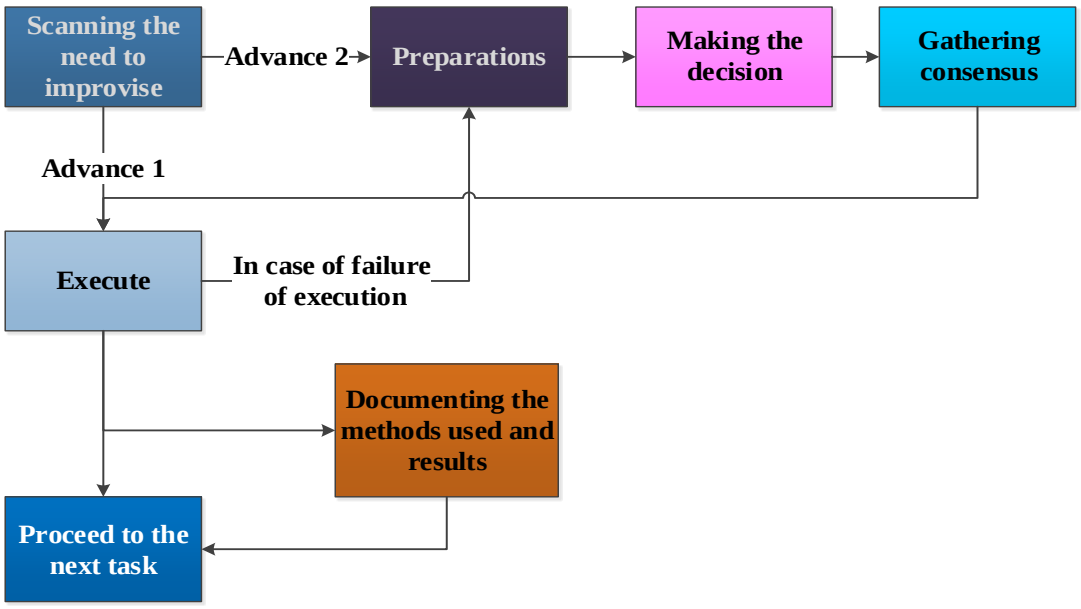

Figure 4-Decision Making Flow Chart

A. Scanning the need to improvise:

In order to identify if there is a need to improvise the improviser has to check the following:

1- If the task prerequisites are ready

2- If we are confident they will be ready on time

3- If the planned procedure can be improved

If any prerequisite is missing or the improviser is not confident it would be ready on time, thus there exists a need for improvisation in order to resolve the situation and start the task on the scheduled time. In addition, if the improviser identifies an opportunity to improve the current plan he also needs to proceed in the process of improvisation. The flow chart below describes the steps in this stage.

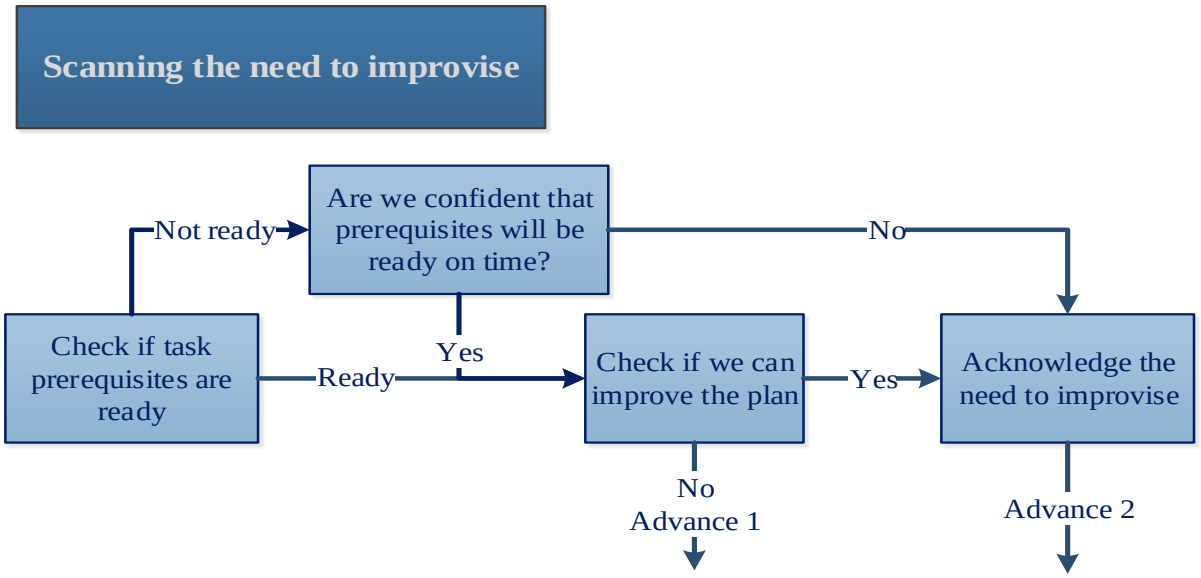

Figure 5-Scanning the need to Improvise

B. Preparations:

At this stage the improviser has identified the need for improvisation and starts to organize his thoughts in order to reach the suitable solution. In order for the improviser to prepare himself, he can go through one or many of the following steps:

1- Share relevant information with others

   i) Share all information available through formal and informal networks

   ii) Share part of the information available through formal and informal networks

2- Recall information from past personal experience

3- Refer to organization's core values

4- Refer to formal documents containing experimental results

5- Reformulate the goals to fit the available solutions (least mental effort)

6- Ask the team for help

7- Pass the problem to the managers to avoid liability

8- Refer to standard operating procedures

   7.1.1. Give new definitions for parts of the planned procedures (adapt procedures to current situations)

   7.1.2. Insert new ideas relevant to current standard operating procedures

9- Break out from conventional methods and think outside the box

10- Recombine resources in different ways than previously planned

11- Come up with entirely novel procedure that doesn't resemble any previous actions

12- Bench mark the working procedures of leading organizations and start improving from there.

The flow chart below sums up the steps in this stage:

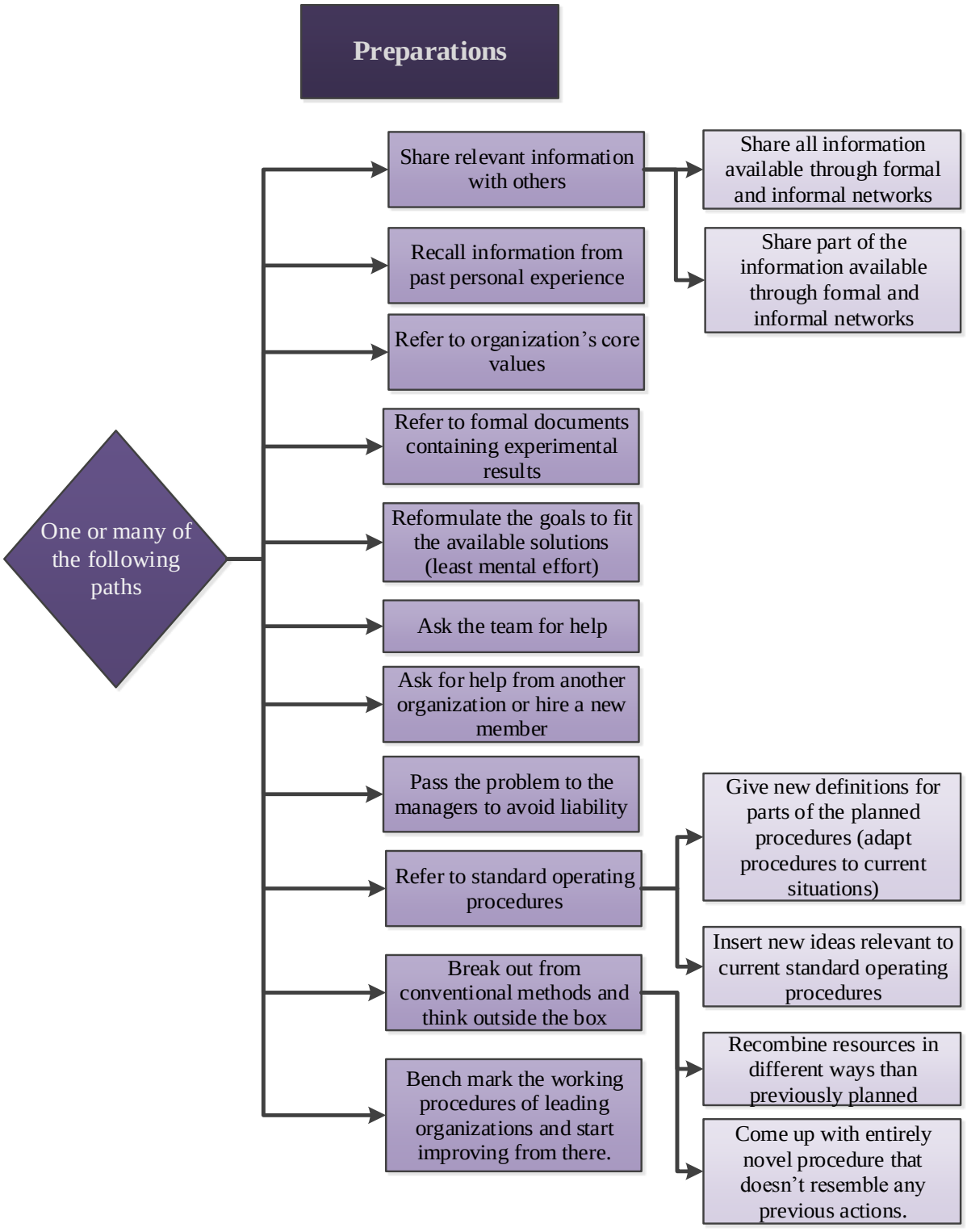

Figure 6-Preparing to improvise

C. Making the decision:

After acknowledging the need to improvise and preparing to choose the suitable solution the improviser proceeds to either generating different alternatives or he could only consider one satisfactory solution. Then he can mentally simulate the different alternatives or perform first runs to test the effectiveness of the different possible solutions. Afterwards risk of failure could be assessed in order to help us make a more informed decision. According to the time and resources constraints he can pick a satisfying solution or he could go with the optimum one producing the least amount of waste. However if the improviser considers that the improvised decision is associated with a non-acceptable risk of failure, he could delay the task or else commit to perform the improvised decision. The flow chart below describes the process in this stage.

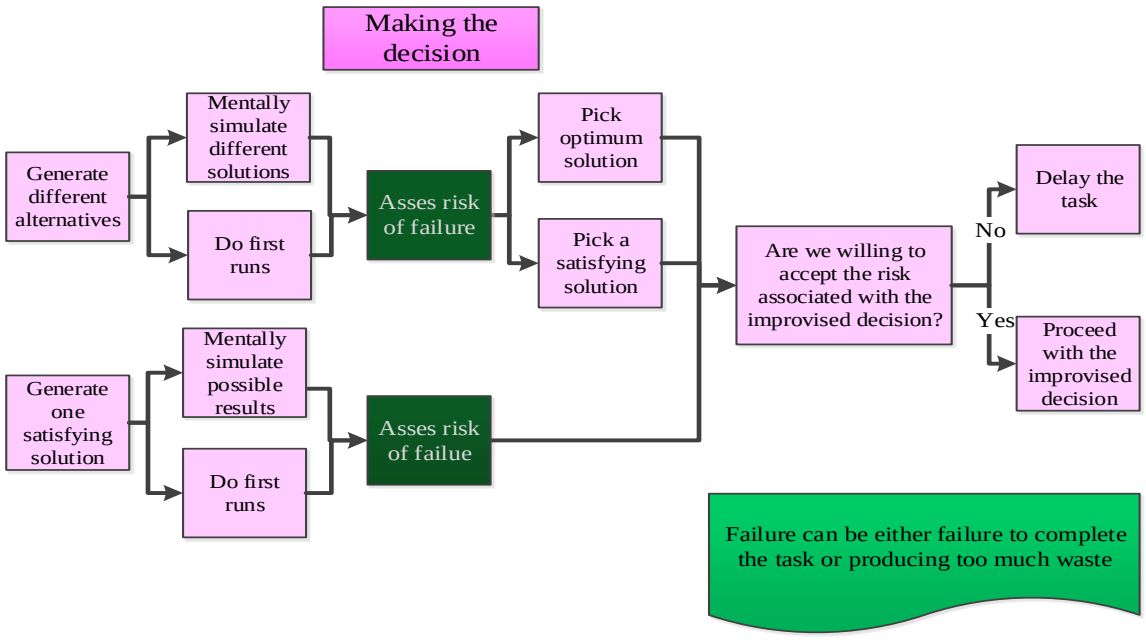

Figure 7-Making the Decision

D. Gathering consensus:

After making the decision the improviser can proceed to gather consensus around the improvised decision. He could consult within the team or even with other teams working on the task. If high internal coherence was gathered around the improvised decision then probably the improviser would proceed with the improvised decision. On the contrary if the consulted colleagues did not agree on the improvised decision, the improviser has to assess his willingness to hold liability of the improvised decision so he could either delay the task or proceed to execution.

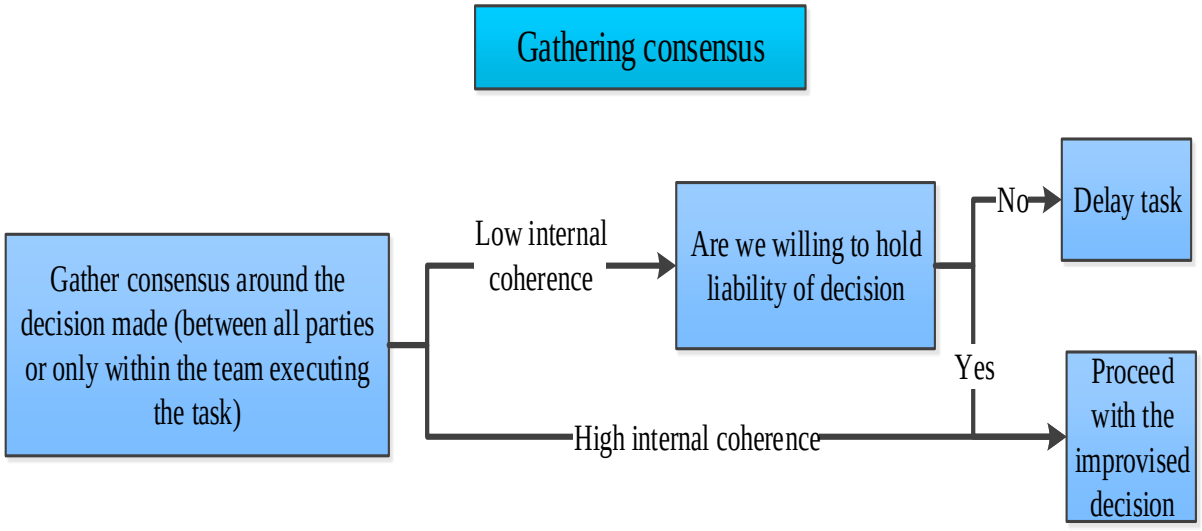

Figure 8-Gathering Consensus

E. Documenting the used methods and results:

This step may not be applied in many construction organizations. However, documenting the results and methods used can help improve improvisational practice in the future. After documenting the results obtained these outcomes should be shared with other teams by sharing the feedback immediately. Hence, if these results were considered unsatisfactory by any team working on the project, they have the chance to take corrective actions.

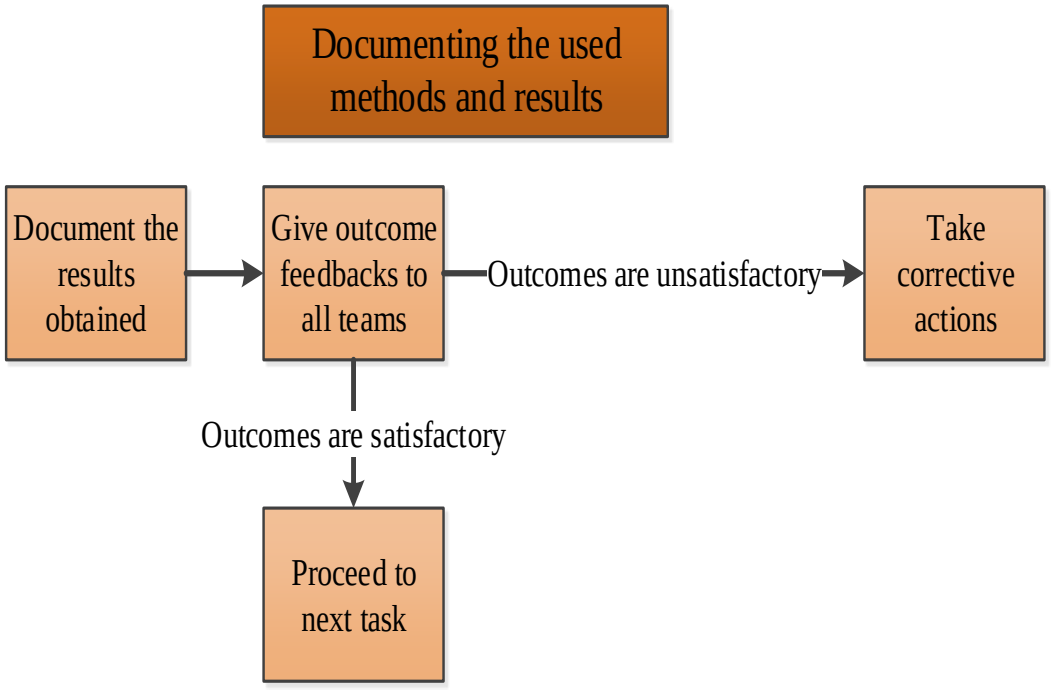

Figure 9-Documenting the used methods and results

5.1.3. Consequences:

In order to sort the different outcomes of improvisation, a typology was developed to differentiate between the different types of improvisation. The author can distinguish between different types of improvisation based on various criteria. In this study the author differentiated between 3 groups of factors upon which different types of improvisation can be identified. The first group contains the possible outcomes; the second group includes the different causes of improvisation, and the third group sums up the factors that characterize improvisation. The following section presents the suggested typology depending on the three groups of factors mentioned earlier:

5.1.3.1. First group: outcomes of improvisation

Based on the performed literature review, the following possible outcomes of improvisation were aggregated.

1- *Emerging level of waste:* where improvisation may be considered to generate one or a combination of the following types of waste :

- Increase in the usage of resources
- Increase in cost
- Increase in the duration of the project
- Decline of quality
- Decrease in safety performance
- Decrease in productivity

- Increase in the complexity of task controls
- Adverse effect on workers' morale

And based on the emerging level of waste ne can distinguish between:

- Tinkering ➔ High level of produced waste
- Successful improvisation ➔Where no waste have resulted from this improvisation

2- *Speed of improvisation:* Improvisation is frequently accompanied by time pressure. Hence the time taken to acknowledge the need to improvise, figure out the suitable improvisational decision and finally take action is a crucial factor for improvisation. Thus the author differentiated between:

- Swift improvisation ➔High speed improvisation
- Slow improvisation ➔Low speed improvisation

3- Novelty of output :

- Unpredicted improvisation ➔The improvisation results in new types of uncertainties or unexpected outcomes
- Expected improvisation ➔The improvisation results in the expected types of outcomes (the outcomes and goals were clear at the start of improvisation and appear as expected)

4- Level of coherence :

- Solo improvisation ➔ Performed by one individual solely.
- Joint improvisation ➔ Performed by a group of members.

- Controversial improvisation➔Improvisation decision raises arguments and different points of view.
- Agreed upon improvisation➔ high internal coherence is gathered around the improvisation decision.

5- *Percent of task completed:*

- Full improvisation ➔The task is performed from the first attempt to improvise
- Partial improvisation ➔ Part of the task is performed at the first attempt to improvise or some of its constrains are removed

Here 2 additional types of improvisation can further be distinguished:

- Incremental improvisation where the task is performed through separate improvisational incidents building on each other.
- One strike improvisation where the task is performed from the first improvisational attempt.

6- *Flexibility of solution:*

As more alternative solutions are available for a certain problem, the improviser is given more flexibility against any unexpected uncertainties. And thus the author differentiated between:

- Flexible improvisation➔Different alternatives can be adopted to resolve the given situation
- Stiff improvisation➔One alternative is presented to solve the problem

Furthermore, using these types of improvisation the consequences of improvisation can be framed as varying between two extreme families of improvisation:

1- Optimum improvisation: which groups the characteristics of successful, swift, expected, full, flexible and agreed upon improvisation
2- Wasteful improvisation: which groups the characteristics of tinkering, slow, unpredicted, controversial, partial, and stiff improvisation

5.1.3.2. Second group: Stimulants of improvisation

Based on the different stimulants of improvisation discussed in the previous section the author differentiated between the following types of improvisation.

- Improvisation on incomplete kit ➔Improvisation stimulated by a missing prerequisite
- Reactive improvisation ➔Improvisation stimulated by failure in execution.
- Additional improvisation ➔Improvisation stimulated by an opportunity to improve the current state.
- Corrective improvisation ➔Improvisation stimulated by poor definition of scope of work or inadequate early identification and removal of constrains.

5.1.3.3. Third group: Characteristics of improvisation

In this study, improvisation is considered to be characterized by the following group of factors:

1- Novelty of method used:

Based on the method used by the improviser the author distinguished 4 different types of improvisation which are summarized in the table below.

Table 3-Types of Improvisation Depending on the Novelty Method Used

Improvise by giving new definition for planned procedures.	High level of interpretative improvisation
Improvise by recombination of resources in a different way than previously planned (ex: using resources assigned for other tasks in order to execute current task).	Low level of interpretative improvisation
Improvise by insertion of new ideas relevant to current standard operating procedures (convergent with core values of the organization)	Low level of innovative improvisation
Improvise by executing entirely novel procedure that doesn't resemble any previous actions (ex: figure out a way to execute the task without the missing prerequisite)	High level of innovative improvisation

2- *Novelty of input:*

- Novel improvisation➔Occurs when improvising on a new situation that never occurred to any of the crew's members
- Repetitive improvisation➔Occurs when improvising on a situation has occurred to one or many of the teams members thus the solution may be obvious and can be retrieved from ones experience or from the organizational memory

3- *Type of the object of the improvisation:*

- Product improvisation➔ Improvising on a product or on the definition of the task that needs to be performed
- Method improvisation➔ Improvising on the standard operating procedure or the methods normally applied

4- *Risk involved:*

- High risk improvisation➔ waste may be produced or the task may be only partially completed
- Low risk improvisation➔ safe improvisation that most probably will be successful and complete improvisation.

Going back to the first group of factors used to distinguish between the different types of improvisation, the consequences of improvisation can be modeled by framing the performed improvisation as ranging between the optimum and wasteful improvisation. The figure below shows the modeled consequences:

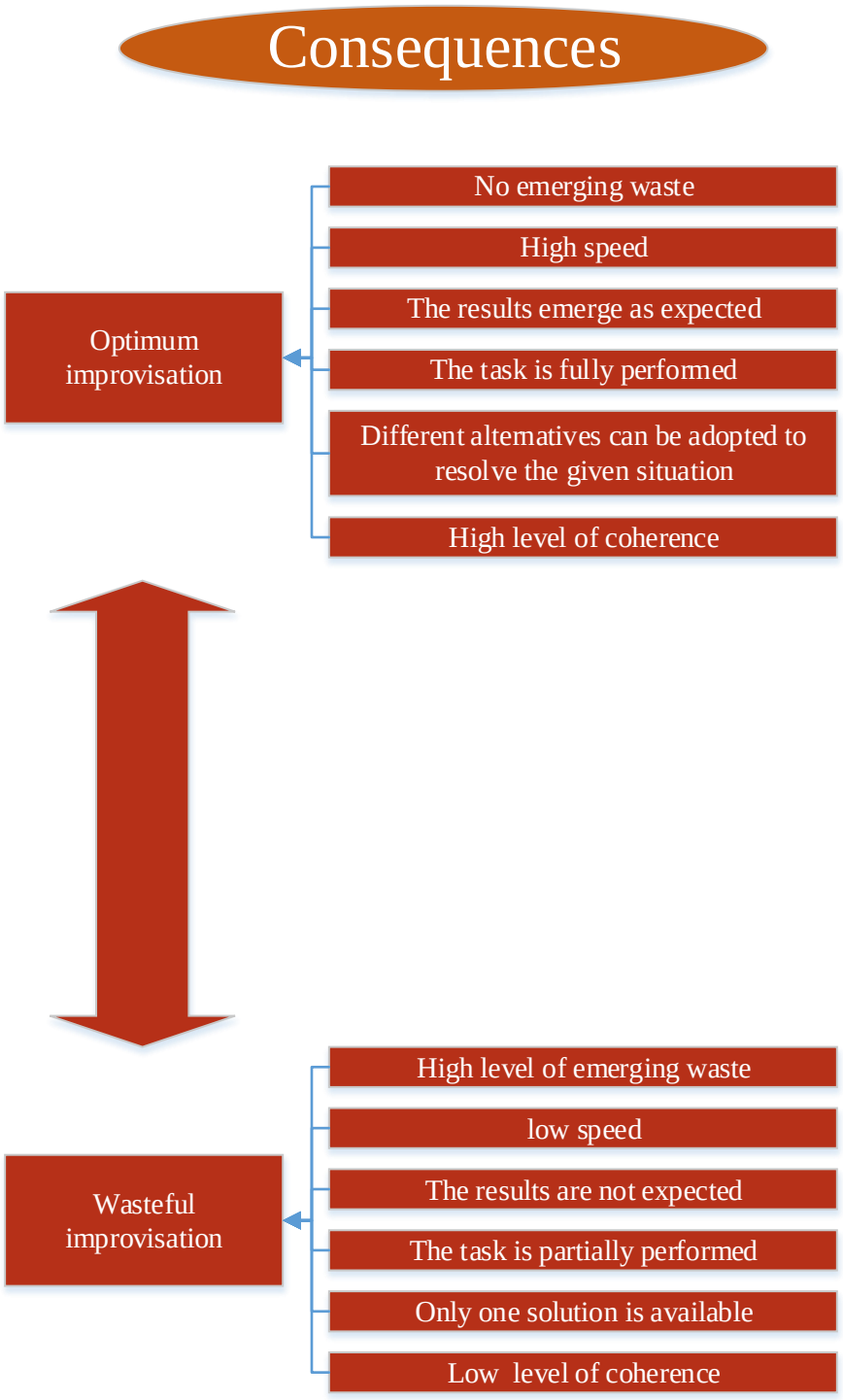

Figure 10-Consequences section of the ABC model

5.2. Developing the survey

In order to analyze the developed ABC model, a survey was developed to collect the necessary data for this study. The survey questions are mainly divided into 6 sections: general information, characteristics of the improviser, characteristics of the organization, causes of improvisation, outcomes of improvisation and used methods. The interviewed worker would respond to each question by ranking on a Likert scale ranging between 1 and 5 his agreement on each statement. 1 being strongly disagree and 5 being strongly agree. The survey contained 20 questions each included several statements. The first draft of the survey was tested through running a pilot survey and then adjusted accordingly. The survey was translated to Arabic so that all workers would be able to fill it. Since the number of factors modeled in the ABC model is large, the author only chooses to focus on some of these factors. Furthermore since some of the modeled characteristics are specific to each incident of improvisation, they cannot be studied through the conducted survey and thus they were not addressed in it.

In the section of the general information the author is interested in gathering information about the improviser's education and experience. No personal information like the name of the worker, or the name of organization he works in was required. In regards of educational background two groups were differentiated: blue and white collar. On the other hand, 3 groups experienced individuals were distinguished: below 5 years of experience, between 5 and 10 years of experience and more than 10 years of experience. As for the characteristics of the improviser the

author only focused on knowing his reaction to risk, whether he is risk averse or risk taking.

Furthermore regarding the characteristics of the organization, the author only chooses to focus on the type of organization. Here three types were distinguished: the empowering organization, the average organization and the traditional knowing organization; where the empowering organization is considered to have characteristics similar to the learning organization defined previously. Guided by the survey done by Garvin et al. (2008), a set of 14 questions was developed that would help us gain insight about the type of organization present. For further information, refer to question 13 in the survey attached in the appendix.

In addition, the author only emphasized on two outcomes indexes: the level of emerging waste and the percent of task completed. The questions asked aimed to gather general information about the frequent level of waste witnessed and whether partial or complete improvisation is practiced more in the construction field. The procedure used to calculate the level of emergent waste is discussed in the following section. Whereas the percent of task completed is considered as the response to one of the survey questions reflecting the interviewer's agreement to the statement that the task is fully executed from the first attempt to do so while improvising.

On the other hand, the survey included questions to help determine the frequent types of uncertainties present in the work environment. Moreover, the survey included several questions that intended to gather information about each of the six stages of the modeled decision making process; starting from scanning the need to

improvise, preparation stage, making the decision, gathering consensus to executing and documenting the results. Finally the interviewed individuals were asked to give their opinion about the most significant characteristic of the improviser and organization that would enhance the practice of sound improvisation. They were also asked to identify the most helpful type of training that could improve the practice of improvisation in their work environment.

To sum up, the survey was developed to gather data in order to analyze the 3 sections of the developed ABC model:

I. To analyze the stimulants section, the most frequent cause of improvisation was studied.
II. To analyze the behaviors sections, the author chose to study the following:
    i. The most frequently used method to improvise.
    ii. The improvisation method that is considered most effective (i.e. Producing the least amount of waste while completing the required tasks)
    iii. If consensus is gathered when improvising in construction.
    iv. If different alternatives are considered before executing the improvised decision.
    v. The type of preparation that is most frequently performed.
    vi. If the risk of failure is assessed before executing the improvised decision in construction.

vii. If improvisers document the results of their improvisation.

viii. The types of uncertainties that are more encountered while improvising.

ix. The identity of the improviser practicing improvisation more frequently (blue collar, white collar or teams working together)

x. The type of training which is considered most effective (several types of training will be discussed).

III. To analyze the consequences sections, the author chose to study the influence of the following factors on the two outcomes indexes: the level of emerging waste and the percent of task completed.

i. Experience

ii. Education

iii. Type of organization

iv. Novelty of input

And finally the author chose to study what personal and organizational characteristic are considered to increase the chances of successful improvisation among individuals who scored low level of emerging waste.

Two copies of the Arabic and English surveys are attached in the Appendix for further information.

5.2.1. Gathering Data

The process of gathering data was done through visiting sites and performing structural interviews. During 4 months, a total of 28 projects were visited in Beirut-Lebanon. The majority of these projects were large projects having more than 100 individuals working on them. The figure below shows one of the structural interviews performed.

Figure 11-Structural interviews held to gather data

Before visiting the sites, I first needed to attain the contractor's permission to visit the sites and fill some surveys. A group of 3 individuals were often gathered to fill the survey at the same time. First, I used to introduce myself and the topic of my research and then I would start reading the questions and explaining the unclear points if there were any. The figure below shows a group of engineers filling surveys in one of the visited projects.

Most of the interviewed individuals especially the blue collar workers refused to fill the survey since they had no time to spare. In about 4 projects I was able to fill a total of two surveys only.

Furthermore, I noticed that many individuals working in the same organization and on the same project but on different teams responded differently when asked about the type of their organization. This may be referred to the fact that the work environment in each team was derived from the mentality of the manager and not from the core values of the organization. Moreover, these responses were highly affected by the employee's perception of his organization and thus can vary a lot from one individual to the other.

Another difference in the points of view was noticed between the engineers working for the contractor and those working for the consultant. That may be explained by the fact the engineers working with the consultant hold no liabilities of delays, thus they place more emphasis on the quality of work and only improvise to improve that. More to the point, if the improvisation was associated with any slight risk of declining the quality of work, they tend to avoid it.

CHAPTER 6

DATA ANALYSIS

A total of 120 surveys were filled. 51 of these surveys were filled by blue collar employees and the rest 69 surveys were filled by white collar employees. The table below sums up the means and standard deviations for the different questions in the conducted surveys.

Table 4-Summary of collected data

Questions asked		Mean	б
Causes of improvisation	Missing prerequisites	3.57	1.22
	Inadequate definition of tasks	3.13	1.11
	Opportunities to improve ready and sound tasks	3.96	0.93
	New circumstances during execution	4.03	0.92
Novelty of the emerging situation	High novelty	3.35	1.26
	Low novelty	3.53	1.26
Level of emerging waste	Increase in the usage of resources	3.27	1.29
	Increase in cost	3.22	1.20
	Increase in the duration of the project	2.64	1.26
	Decline of quality	2.43	1.19
	Decrease in safety performance	2.60	1.24
	Decrease in productivity	2.49	1.22
	Increase in the complexity of task controls	2.98	1.24
	Adverse effect on workers' morale	2.63	1.19
Frequency of the method used	Giving new definition for planned procedures.	3.60	1.02
	Recombining resources	3.64	1.07
	Coming up with new ideas relevant to current standard operating procedures	4.08	0.85
	Coming up with entirely novel procedures	2.94	1.28

Effectiveness of the method used	Giving new definition for planned procedures.	3.35	1.01
	Recombining resources	3.38	1.01
	Coming up with new ideas relevant to current standard operating procedures	3.69	0.98
	Coming up with entirely novel procedures	2.92	1.23
Type of uncertainties	It is hard to recognize the need for improvisation	2.70	1.13
	The methods of improvisation needed to resolve the situation and reach the goals are unclear	3.07	1.15
	Goals are ill-defined and vague	2.79	1.29
	The environment is rapidly changing and it is difficult to keep data up to date	3.24	1.17
The considered alternatives	Different alternatives are generated and assessed	4.02	0.99
	The first solution encountered is executed even if it not the optimum one	2.45	1.21
Gathered consensus	Consensus is gathered between managers in the team responsible for executing the task	3.94	0.93
	Consensus is gathered between all team members	3.50	1.18
	No consensus is gathered	2.47	1.22
	All parties should agree upon improvisational action else it is abandoned	2.77	1.25
Identity of the improviser	Managers only	2.68	1.29
	Workers who are given information about task status	3.23	1.06
	Teams that work collaboratively to share experience and improvise better	3.97	1.00
Required training	Training to know wide set of routines and procedures well	3.88	1.05
	Training to learn high level concepts rather than procedures	3.79	1.01
	Training to enhance the worker's ability to generate different alternatives	4.07	0.93
	Training to improve the worker's ability to handle pressure	4.02	1.00
Type of organization	Employees are not encouraged to improve or rethink the way tasks are done.	2.72	1.28
	Regulations and standards should never be altered	2.95	1.22
	When mistakes occur, investigations are held to find who should be blamed	3.40	1.28
	Employees are encouraged to learn about their own jobs and divisions, but not about the relationships with other jobs and divisions.	3.19	1.18

Type of organization	Managers inform employees about company's performance and plans and provide networks of communications between employees and company's top executives	3.34	1.21
	Failure is expected, even desirable	3.17	1.22
	Managers encourage employees to think creatively and enhance the task they are doing	3.64	1.22
	Differences in opinions are welcomed to motivate fresh thinking	3.75	1.09
	Employees are overstressed with deadlines and have no time to innovate and think of new methods to resolve emerging situations	3.34	1.16
	All units are eager to share information.	3.37	1.11
	Information is available and easy to access	3.53	1.00
	Root causes of problems are analyzed to be resolved	3.57	1.05
	Managers command rather than coordinate	3.30	1.25
	Giving employees the freedom to experiment with the process makes it difficult to control the process	3.12	1.13
Percent of task completed	All constraints are removed and the task is fully executed from my first attempt to improvise	3.01	1.10
Preparing to improvise	Recall information from past personal experience.	4.19	0.90
	Ask the team to help by sharing experience and learning that was not formally documented in the past.	3.90	1.01
	Ask for help from another organizations that would be willing to share their knowledge	2.83	1.29
	Refer to standard operating procedures.	3.60	1.04
	Pass the problem to managers without trying to solve it.	2.08	1.05
	Break out from conventional methods and think outside the box	3.65	1.03
	Hire a new member that has experience in solving similar problems.	2.81	1.13
	Benchmark the working procedures of leading organizations in the industry	3.43	1.08
	Try to redefine the problem to fit available solutions	3.90	0.86
Risk Assessment	The improviser assess Risk of failure	3.91	1.14
Documenting the results	Document Results and give a degree of satisfaction	3.63	0.98
	Use a computer based network to store information.	3.38	1.30
	Quickly share Feedback about improvisation outcomes to give time for corrective actions.	3.93	0.95

Improviser's reaction to risk	The improviser takes the risk even if it could affect his career	2.66	1.35
Improviser's personal characteristics that can empower improvisation	Reacting well to time pressure	4.24	0.66
	Having experience	4.28	0.86
	Taking risk	3.73	0.86
	Open to experimenting	3.96	0.95
	Ability to communicate with others	4.30	0.86
Characteristics of the organization that can empower improvisation	Empowers the employees	3.86	1.11
	Allows employees to brake some regulations and rules when necessary	3.13	1.16
	Allows experimenting in order to find suitable solution (Biased towards action)	3.47	1.10
	Tolerates non optimal solutions	2.95	1.10
	Defines the roles and responsibilities for each employee	4.03	0.83
	Practices good planning procedures	4.11	0.87
	Stores learning and keeps records	3.96	0.99
	Allows giving authority to the employee with more experience in the relevant field	3.89	0.89

6.1. The level of emerging waste

The survey included a question asking about the emergence of 8 different categorizes of waste due to improvisation. The interviewed individuals were asked to rank how frequently the following 8 types of waste emerge due to improvisation: w1- Increase of the usage of resources; w2-Increase in cost; w3- Increase in the duration of the project; w4-Decline of quality; w5- Decrease in the safety performance; w6- Decrease in the productivity;w7- Increase in the complexity of task controls; w8- Adverse effect on workers' moral. In order to evaluate the emerging level of waste, exploratory factor analysis was used to group the different variables gathered into one latent variable.

Another method that could be used is primary component analysis (PCA). The difference between exploratory factor analysis and PCA is that PCA uses the total variance in the computation process and thus derives factors that contain unique factor variance and error variance. On the other hand, exploratory factor analysis derives factors that only contain the shared variance (Mindrila, 2013). However, PCA doesn't correlate the different factors into one latent variable, but develops a linear combination of the measured variables. On the contrary common factor analysis groups all factors into one latent variable (Mindrila, 2013). Furthermore, Baglin, J. (2014) distinguished between exploratory factor analysis and PCA by stating that PCA is mainly used as a data reduction method while EFA is used to identify an underlying factor structure that explains the relationships between the observed variables.

Since the author was dealing with ordinal data some adjustments are advised for the conventional EFA method. Normally EFA is based on Pearson correlation matrix; however studies have shown that it underestimates the strength of the relationships between the ordinal data and thus leading to biased factor loadings (Baglin, J., 2014). Instead of the Pearson correlation matrix scholars use Polychoric correlation matrix when dealing with ordinal data since it is considered as a less biased estimator.

Furthermore, Baglin, J. (2014) suggested using parallel analysis for factor retention decisions instead of Kaiser Criteria and Scree plots. Scree plots and Kaiser Criteria are suitable for having an idea about the number of factors to be considered,

however parallel analysis is considered to outperform them both. Parallel analysis uses the mean Eigen values of different randomly generated datasets (after being analyzed by PCA) to compare it to the sample Eigen values. Then only the factors with Eigen values greater than the means of the generated samples are retained (Baglin, J., 2014).

In addition oblique rotation was recommended by Baglin, J. (2014) instead of orthogonal rotation when dealing with ordinal data. Since most factors that produce the latent variable are expected to be correlated even in low degrees, scholars have advised using oblique rotation that allows components to share some degree of relationship (Baglin, J., 2014).

On the other hand, principal axis factoring is used as the extraction method since it assumes no distributional assumptions (Baglin, J., 2014).

The data in the appendix shows the results of the rank of 8 waste categories collected by the survey. The author aims to group them into a latent factor using EFA. In order to do that, R studio is used with the help of the code written by Wollschlaeger (2014).

The parallel analysis for the data resulted in the following scree plot and since the elbow of the curve for actual data factor analysis is located at one principle latent component, thus the number of recommended factors for EFA is equal to 1.

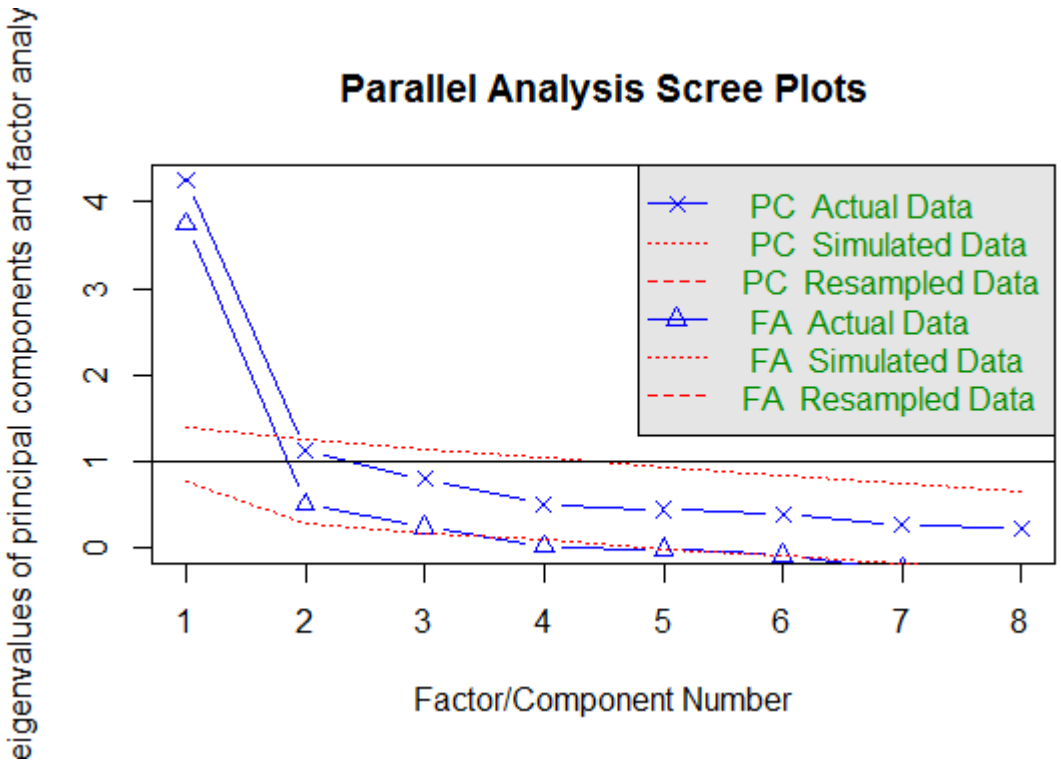

Figure 12-Parallel Analysis Scree Plots

The following results were obtained after running exploratory factor analysis using principle axis factoring as the extraction method with number of factors=1, number of observations =120, with oblique rotation and based on polychoric correlation matrix.

```
Factor Analysis using method = pa

Call: fa.poly(x = d.A, nfactors = 1, n.obs = 120, rotate
= "oblimin", fm = "pa", scores = "regression",
oblique.scores = TRUE, cor = "poly")

Standardized loadings (pattern matrix) based upon
correlation matrix

    PA1   h2   u2 com

w1 0.50 0.25 0.75   1
```

```
w2 0.65 0.42 0.58   1

w3 0.73 0.54 0.46   1

w4 0.76 0.58 0.42   1

w5 0.67 0.46 0.54   1

w6 0.76 0.58 0.42   1

w7 0.66 0.43 0.57   1

w8 0.69 0.47 0.53   1

                  PA1

SS loadings    3.74

Proportion Var 0.47

Mean item complexity = 1

Test of the hypothesis that 1 factor is sufficient.

The degrees of freedom for the null model are 28and the
objective function was 3.92 with Chi Square of 452.29

The degrees of freedom for the model are 20 and the
objective function was 0.88

Measures of factor score adequacy

                                                 PA1

Correlation of scores with factors              0.94

Multiple R square of scores with factors        0.88

Minimum correlation of possible factor scores   0.76
```

The author concluded from those results that the use of one factor in the EFA is sufficient and that the latent variable PA1 explains 47% of the variation in the data.

After deriving the scores of PA1 from each set of 8 variables, a vector of 120 variables each representing a set of 8 variables reflecting the different types of waste

was obtained. These scores ranged between -2 and 2 where 2 reflects the highest level of waste and -2 the lowest level of emerging waste. In this study the author named PA1 as the emerging level of waste. The histogram below shows the frequency of the obtained scores.

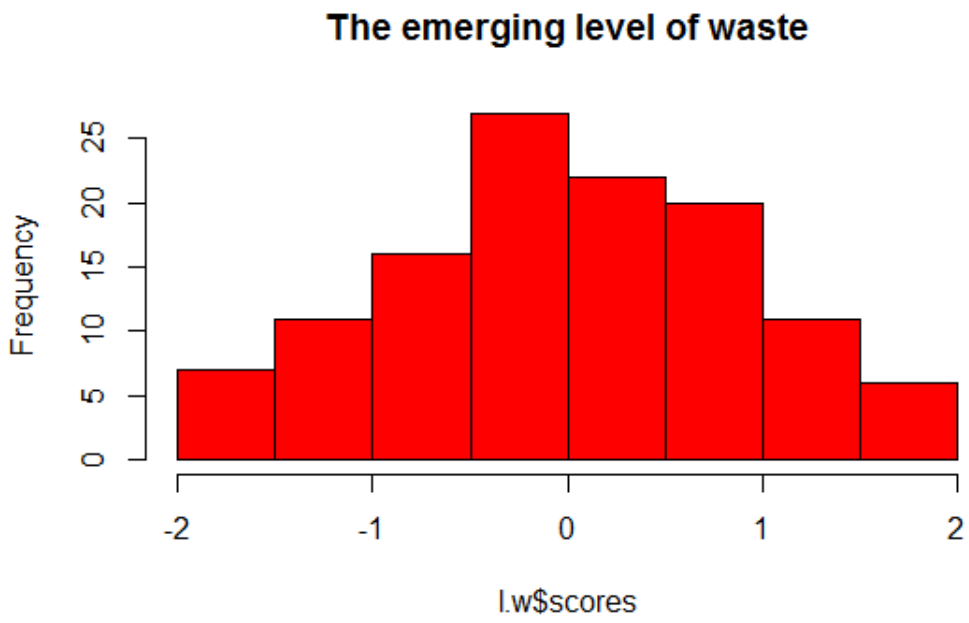

Figure 13-The level of emerging waste

The scores of emerging level of waste for each survey were stored in the variable l.w. A table containing these scores is attached in the appendix. In order to visualize the loading factors of each component into the latent variable PA1 or the emerging level of waste, the following plot was generated.

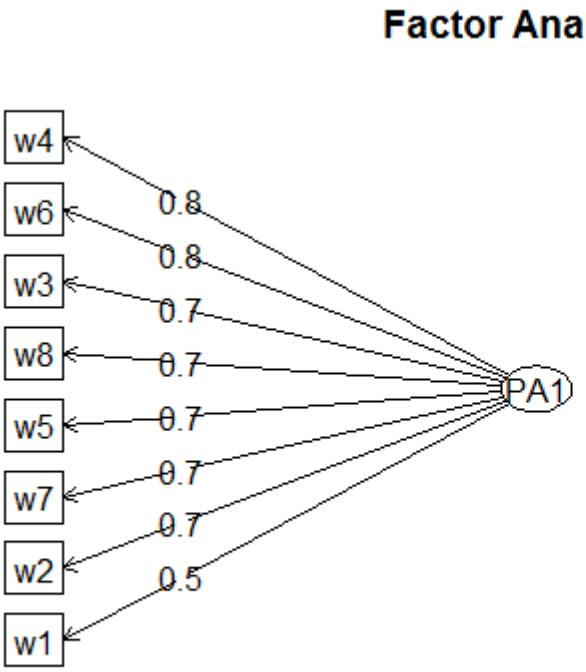

Figure 14-The loading factors of each component into the latent variable PA1

In the data analysis the following statistical tests were used:

- The ANOVA test which assumes normal distribution of data and all that groups analyzed share equal variances.
- The Kruskal-Wallis rank sum: a non-parametric test that does not assume any distribution for the analyzed data. Then pair-wise comparisons was used using Wilcoxon rank sum test with holm as the p-value adjustment method to identify the groups that are significantly different.
- T-tests assume that the data is normal
- The non-parametric Mann-Whitney test that does not assume any distribution for the analyzed data but assumes equal variances

- "var.test" function to study if the two groups share equal variances
- Bartlett test to study equal variances across more than 2 groups
- The Shapiro test to study normality within the groups analyzed

6.2. Studying the most frequent cause of improvisation

In the stimulants section of the ABC model four different causes of improvisation were defined. In order to study which cause is most frequently encountered in the construction field, the survey included a question that aimed to gather the necessary data. The distribution of the collected data relative to each of the four causes is shown in the box plot below:

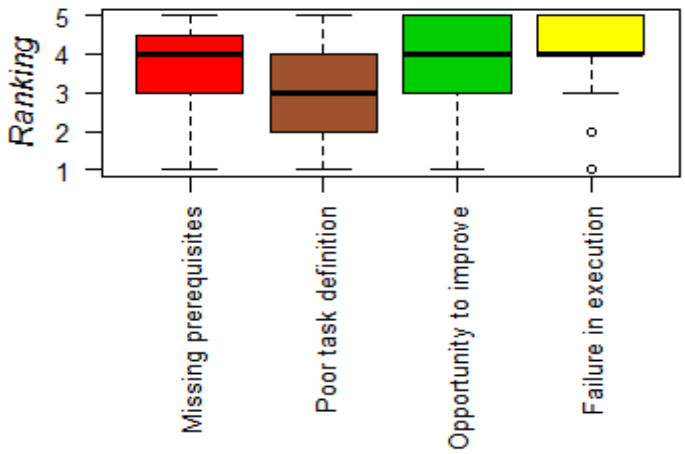

Figure 15-Ranking of the four different causes of improvisation

An ANOVA test can be performed to help us analyze the collected data and identify the most frequent cause of improvisation in construction. The following p-values were obtained when studying for normality:

1- Missing prerequisites ➔ p-value= 1.117e-08

2- Poor task definition➔ p-value= 4.962e-07

3- Opportunity to improve ➔ p-value= 1.712e-09

4- Failure in execution➔ p-value= 3.691e-10

Thus enough evidence exists to reject normality in the four groups. Hence the Kruskal-Wallis rank sum test was used and obtained a p-value= 1.279e-10. Hence with 90% confidence level the null hypothesis that all of the four groups are the same can be rejected. Further pair-wise comparisons were used using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 5-The p-values from the pair-wise test

Causes	1	2	3
2	0.0063	-	-
3	0.0489	3.70E-08	-
4	0.0133	1.10E-09	0.4956

Therefore, with 90% confidence interval the results show that all groups are significantly different except for groups 3 &4. *Hence failure in execution and seeing opportunities to improve ready and sound task are the most frequent causes of improvisation in the construction industry. The identification of missing prerequisites is less frequent than the previous 2 causes. And finally poor definition of scoop of work can be considered as the least frequent cause.*

6.3. Studying the influence of experience on the emerging level of waste

3 groups of experienced workers having were distinguished:

1- less than 5 years of experience

2- between 5 and 10 years of experience

3- more than 10 years of experience

The collected surveys were filled by 35 individuals with experience less than 5 years, 36 individuals with experience ranging between 5 and 10 years and 49 individuals with experience more than 10 years. In order to study the effect of experience on the level of emerging waste, the analysis of variance test is used. First the level of waste in the 3 defined groups of experienced workers was plotted:

Figure 16-The level of emerging waste according to the 3 groups of experience

First to test for equal variances, Bartlett test is used. The obtained p-value= 0.001399 thus the author can reject that the three groups share equal variances. Hence

the ANOVA test cannot be used. The Kruskal-Wallis rank sum test was used and the author obtained a p-value= 0.06897. Hence the null hypothesis that all of the three groups are the same can be rejected. In order to identify the group that is significantly different from the others, pair-wise comparisons was used using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 6-The p-values from the pair-wise t-test

Group	1	2
2	0.388	0.072
3	0.072	0.388

With a 90% confidence level the results show that group 3 is significantly different from groups 1 and 2. But on the other hand, groups 1 and 2 show no significant difference. *Thus individuals with experience more than 10 years practice improvisation with lower level of emergent waste than those having less than 10 years of experience.*

6.4. Studying the influence of experience on the percent of task completed

Here 2 groups of employees were distinguished:

1- Individuals having experience less than 10 years

2- Individuals having experience more than 10 years

The collected surveys were filled by 71 individuals with experience less than 10 years and 49 individuals with experience more than 10 years. In order to study if experience has a significant effect on the percent of task completed, at-test was ran using R software. Then Shapiro test was used and the following p-values were obtained: first group (<10 years of experience) has a p-value= 3.385e-06and the second group (>10 years of experience) has a p-value= 0.0005469. Hence normality was rejected in both cases.

After confirming that the two groups share equal variances, the non-parametric Mann-Whitney test with the “less” alternative option was used (i.e. the null hypothesis states that the median of the first group is greater than that of the second group). The p-value obtained= 0.0003843. Hence with 90% confidence level the author can reject that the mean percent of task completed during improvisation made by individuals having experience less than 10 years is greater than that during improvisation made by individuals having experience more than 10 years. *Thus conclude that experience has a positive significant effect on improving the percent of task completed by the improvisation.* The box plot below shows the variation of the percent of task completed in the two groups.

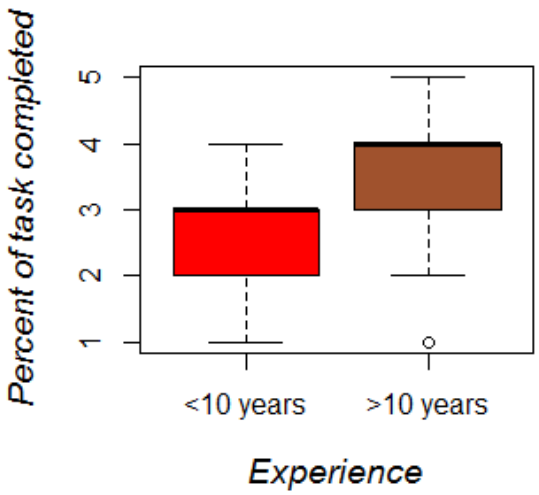

Figure 17-The percent of task completed according to the 2 groups of experienced employees

6.5. Studying the influence of education on the emerging level of waste

2 groups of workers were distinguished:

1- Blue collar

2- White collar

The collected surveys were filled by 69 white collar employees and 51 blue collar employees. Shapiro test was used to study normality within each of the two groups of surveys and the following p-values were obtained: the blue collar group has a p-value=0.1734 and the white collar group has a p-value= 0.6771. Hence normality cannot be rejected in both cases. Then “var.test” function was used to study if the two groups share equal variances. The p-value obtained was 0.03006 thus the author

rejected that the two groups have equal variances. Hence the t-test should not assume equal variances.

After running the t-test the obtained p-value= 0.3586 and thus with 90% confidence interval, the author failed to reject that the two groups are the same. *Thus education fails to show any significant effect on the level of emerging waste when the individual practices improvisation.* The box plot below shows the variation of the level of emerging waste in the two groups.

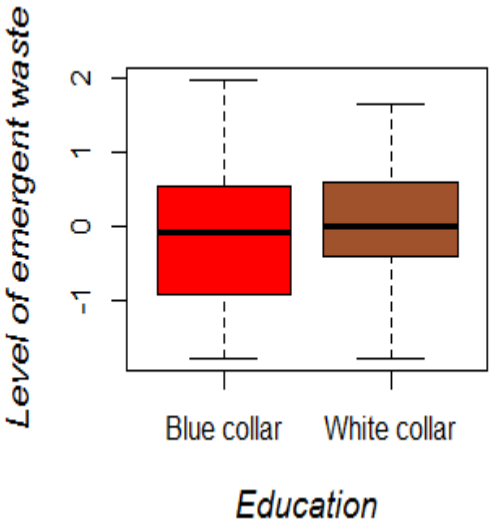

Figure 18-The level of emerging waste according to the education level

6.6. Studying the influence of education on the percent of task completed

Shapiro test was used and the following p-values were obtained: the blue collar group has a p-value= 0.0006027and the white collar group has a p-value= 3.483e-05. Hence normality was rejected in both cases. Thus after confirming equal

variances, the non-parametric Mann-Whitney test was used with the "less" alternative option (i.e. the null hypothesis states that the median of the blue collar group is greater that of the white collar group). The p-value obtained=0.9986. Hence with 90% confidence level the author cannot reject that the median percent of task completed during improvisation made by the blue collar employees is greater than that made by the white collar employees. *Thus education fails to show any significant effect on the percent of task completed when the individual practices improvisation.* The box plot below shows the variation of the percent of task completed in the two groups.

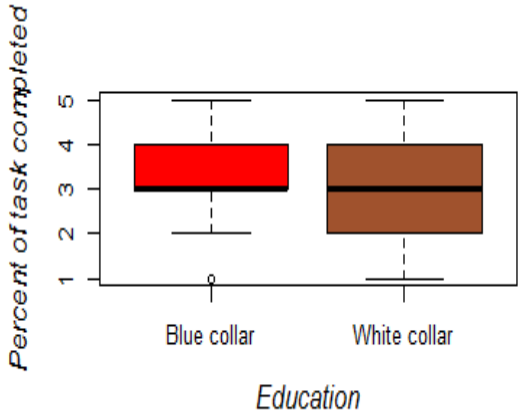

Figure 19-The percent of task completed according to the education level

6.7. Studying the influence of type of organization on the level of emerging waste

With the guidance of the survey developed by Garvin et al. (2008), a set of 14 questions was developed that would help us identify the type of organization of the interviewed individual. These 14 questions are presented in the first 14 statements of

question 13 in the survey. Some of these 14 statements referred to practices applied in a learning organization that empowers its employees to rethink the applied procedures and attempt to improve their work environments. Question 13 in the survey further included statements that referred to practices applied in a traditional knowing organization. First the responses of the negative statements that do not refer to an empowering organization (or a learning organization) where subtracted from 6, then the responses of these 14 statements in question 13 were averaged to group them into one variable. Thus when this averaged score approaches 5 thus the interviewed employee considers his organization as an empowering organization, and when it approaches 1 thus he considers his organization as a traditional knowing one. The histogram below shows the averaged scores that the interviewed individuals gave to their organizations.

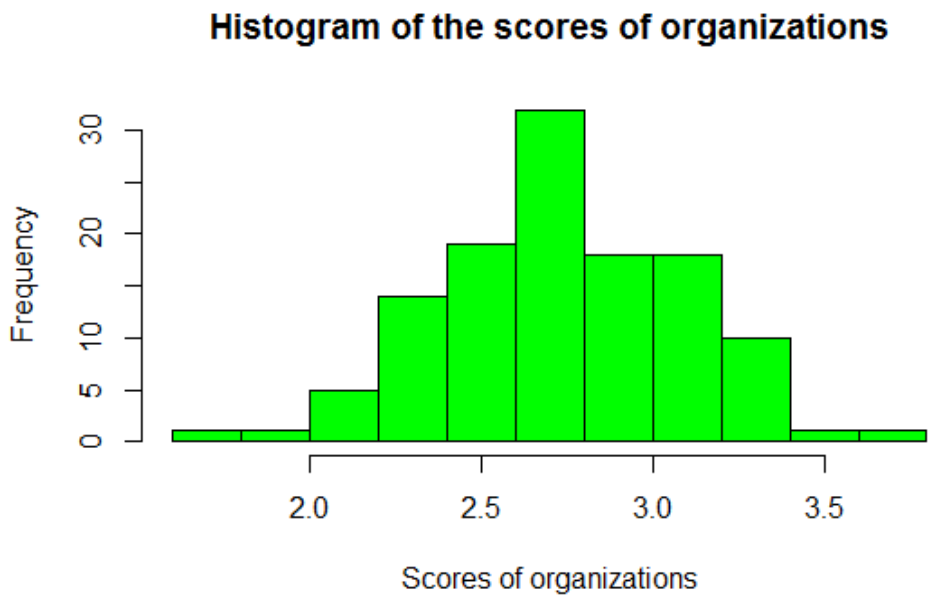

Figure 20-Histogram of the scores of organizations

The author chose to divide the collected data into three groups one scoring between 2.8 and 3.2, another scoring 2.8 and below and the third scoring 3.2 and above. And thus three types of organizations were distinguished: the traditional knowing organization scoring 2.8 and below, the average organization scoring between 2.8 and 3.2 and the empowering organization scoring 3.2 and above. For the statistical analysis the effects of the knowing and empowering organization on the emergent level of waste were only studied. The levels of waste calculated from average organization would not be taken into consideration to make sure that the analysis are differentiating between two different types of organizations.

The collected surveys were filled by 73employees belonging to a traditional knowing organization, 12employees belonging to an empowering organization. In order to study if the type of organization has a significant effect on the level of emerging waste, a t-test was performed using R software. Shapiro test was used and the following p-values were obtained: the knowing organization group has a p-value= 0.3839 and the empowering organization group has a p-value= 0.05281. Hence the author failed to reject normality in both cases. Then “var.test” function was used to study if the two groups share equal variances. The p-value obtained was 0.2565 thus the author failed to reject that the two groups have equal variances.

After running the t-test with the alternative option= “greater”(i.e. the null hypothesis states that the median of the knowing organization group is less than that of the an empowering organization group), the p-value obtained is 0.004626 and hence with 90% confidence level the author rejected that the median level of

emerging waste in knowing organization is less than that in the empowering organization. *Thus the type of organization shows significant effect on the level of emerging waste when the individual practices improvisation. Improvisation in an empowering organization tends to have a lower level of emergent waste*. The box plot below shows the variation of the level of emerging waste between the two groups.

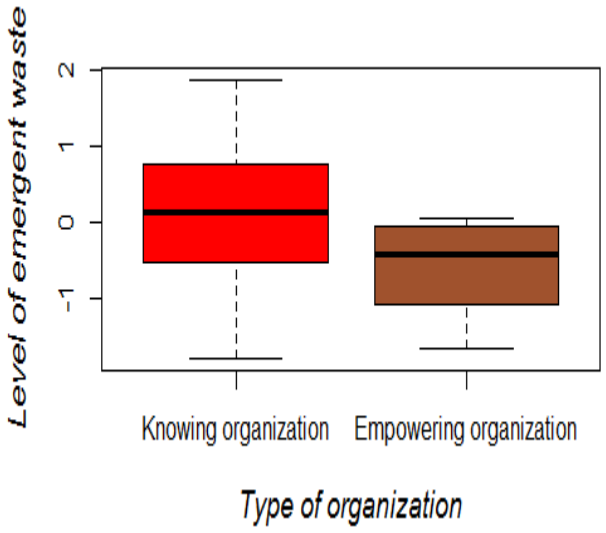

Figure 21-The level of emerging waste according to the type of organization

6.8. Studying the influence of type of organization on the percent of task completed

In order to study if the type of organization has a significant effect on the percent of task completed, a t-test was performed using R software. Shapiro test was used and the following p-values were obtained: the traditional knowing organization group has a p-value= 8.603e-05and the empowering organization group has a p-value= 0.04623. Hence normality was rejected in both cases. Thus after confirming

equal variances, the non-parametric Mann-Whitney test was used with the "two sided" alternative option (i.e. the null hypothesis states that the medians of the two groups are equal). The p-value obtained= 0.475. Hence with 90% confidence level the author cannot reject that the median percent of task completed during improvisation made in a knowing organization is equal to that made in a learning organization. *Thus type of organization fails to show any significant effect on the percent of task completed when the individual practices improvisation.* The box plot below shows the variation of the percent of task completed between the two groups.

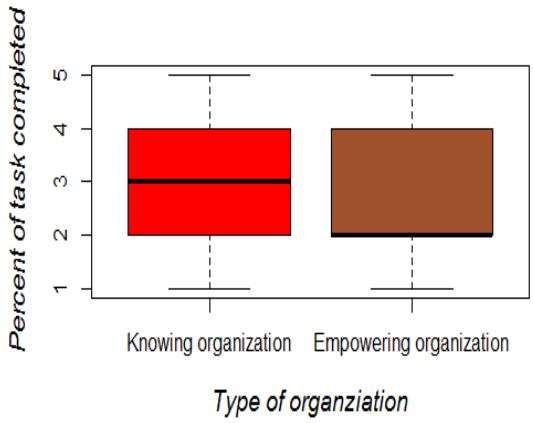

Figure 22-The percent of task completed according to the type of organization

6.9. Studying the effect novelty of input on the level of emergent waste

Question 5 in the survey included two independent opposite statements, one considering that the incidents causing improvisation are new and have never occurred to anyone of the team members, and the other stating the opposite. The responses to both statements were considered in order to get an idea about the degree of novelty of

the input of improvisation the interviewed individual frequently notices. And consequently 3 situations were distinguished:

1- Most of the incidents requiring improvisation are of repetitive nature and have occurred to one or more of the team members (symbol: R).
2- Most of the incidents requiring improvisation are new and have never occurred to one or more of the team members (symbol: N).
3- Both new and repetitive incidents of improvisation are witnessed in the work environment (symbol: B).

30 respondents considered that both new and repetitive incidents of improvisation are witnessed in the work environment (i.e. agreed equally to both statements). However, 39 other respondents believed that incidents simulating improvisation are new. And a majority of 51 respondents considered such incidents to be of repetitive nature. To visualize the variation of the level of emerging waste across the 3 groups previously defined, the following box plot was prepared.

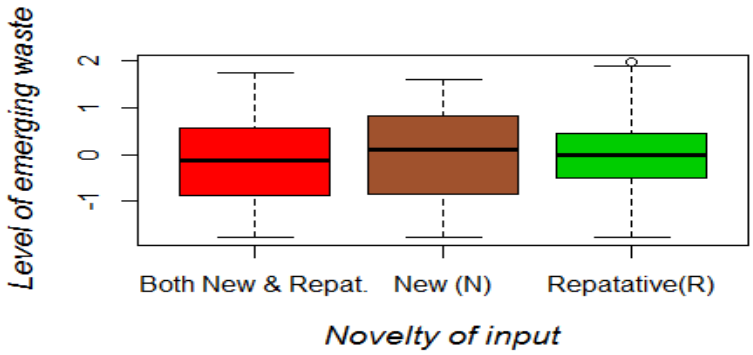

Figure 23-The level of emerging waste according to the novelty of input

The median level of emerging waste does not vary much between the respondents considering the incidents causing improvisation as new and those considering them of reparative nature. But in case of low novelty of input (Repetitive) the variability around the median is less than that noticed in case of high novelty of input (new). Thus for the statistical analysis the author only studied difference between N and R groups on the level of emerging waste.

A t-test is performed to study if the novelty of input has a significant effect on the level of emerging waste. The author only choose to compare the N and R groups. Shapiro test was used and obtained the following p-values: N group p-value=0.1871 and R group p-value= 0.8174. Hence the analysis failed to reject normality in both cases. Then var.test function was used to study if the two groups share equal variances. The p-value obtained was 0.2666 thus the author failed to reject that the two groups have equal variances. Thus the performed t-test could assume equal variances.

After running the t-test the obtained p-value= 0.7733 and thus with 90% confidence interval the author failed to reject that the two groups are the same. *Thus the degree of novelty of the input fails to show any significant effect on the level of emerging waste when the individual practices improvisation.*

6.10. Studying the effect of novelty of input on the percent of task completed

In order to study if the novelty of input has a significant effect on the percent of task completed, a t-test was performed using R software. Shapiro test was used and the following p-values were obtained: N group p-value= 0.00278 and R group p-value= 0.00171. Hence normality was rejected in both cases. Thus after confirming equal variances, the non-parametric Mann-Whitney test was used with the "two sided" alternative option. The p-value obtained= 0.3861. *Hence with 90% confidence level a significant effect of the degree of novelty on the median percent of task completed cannot be proven.* The box plot below shows the variation of the percent of task completed between the three groups defined in the previous section.

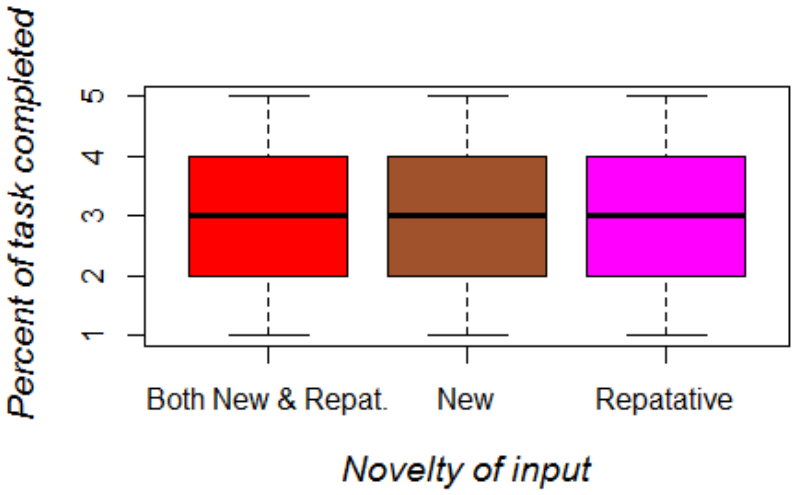

Figure 24-The percent of task completed according to the novelty of input

6.11. Studying which method is most frequently used

Question 7 in the survey included several statements each referring to a method that could be used while improvising. These statements were derived from decision making flow chart that was previously discussed in the previous chapters. Four methods were considered:

A. Improvising by giving new definitions for planned procedures.
B. Improvising by combining resources in a different way than what was previously planned.
C. Improvising by coming up with new ideas relevant to current standard operating procedures.
D. Improvising by executing entirely novel procedures that don't resemble any previous actions.

An ANOVA test can be performed in order to study which one of these methods is most frequently used. The distribution of the collected data relative to each one of the four methods is shown in the box plot below. The method C has the highest rank followed by A &B while D ranks the lowest.

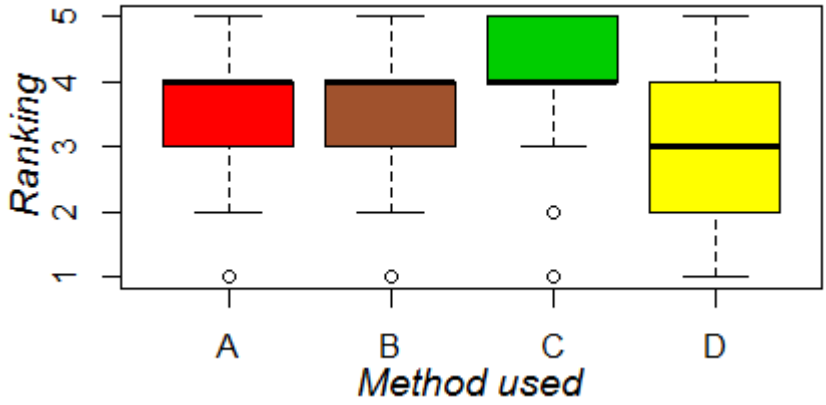

Figure 25-Ranking of the four different methods of improvisation

The following p-values were obtained after running Shapiro test:

1- Method A ➔ p-value= 3.522e-09

2- Method B ➔ p-value= 1.174e-09

3- Method C ➔ p-value= 1.258e-11

4- Method D ➔ p-value= 3.177e-07

Thus the author had enough evidence to reject normality in the four groups. Then the Kruskal-Wallis rank sum test was used and obtained a p-value= 2.978e-12. Hence with 90% confidence level the null hypothesis that all of the four groups are the same was rejected. In order to identify the group that is significantly different from the others pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 7-The p-values from the pair-wise t-test

Methods	A	B	C
B	0.68387	-	-
C	0.00033	0.00134	-
D	0.00011	6.0e-05	1.6e-11

Therefore results show that with 90% confidence interval all groups are significantly different except for groups A &B. *Hence the most frequently used method is improvising by 'coming up with new ideas relevant to current standard operating procedures'. Improvising by 'giving new definitions for planned procedures' and improvising by 'combining resources in a different way than what was previously planned', come next in line and are less frequently used than the method mentioned before. On the other hand, improvising by 'executing entirely novel procedures that don't resemble any previous actions' is the used the least.*

6.12. Studying which method is considered most effective among individuals who scored low level of emerging waste

An improvisation method is considered effective when the improviser using it succeeds to complete the required task while producing the least amount of waste. Hence to study which method is considered effective, the author only examined the data gathered from individuals who scored low level of emergent waste.

73 respondents out of the 120 scored below 0.2 on the level of emerging waste. Their responds to question 7.1 were examined to see which method is

considered most effective. In order to achieve that, an ANOVA test can be performed. The distribution of the collected data relative to each one of the four methods is shown in the box plot below. The ranking of all method is very close.

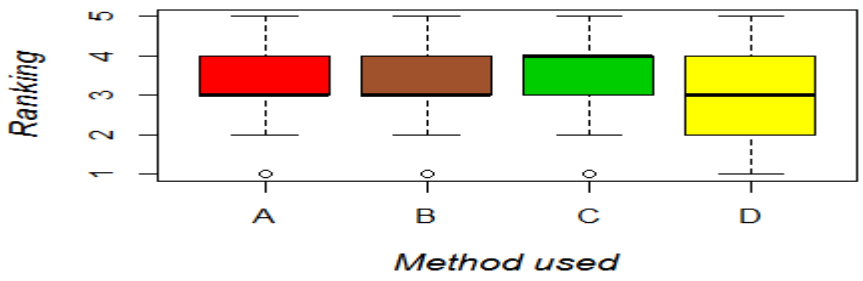

Figure 26-Ranking of the efficiency of the four different methods of improvisation

Shapiro test was used and the following p-values were obtained:

1- Method A ➔ p-value= 1.609e-06
2- Method B ➔ p-value= 1.272e-06
3- Method C ➔ p-value= 4.401e-06
4- Method D ➔ p-value= 5.233e-05

Thus the author had enough evidence to reject normality in the four groups. Then the Kruskal-Wallis rank sum test was used and the obtained p-value is 0.00474. Hence with 90% confidence level the null hypothesis that all of the four groups are the same was rejected. In order to identify the group that is significantly different from the others pair-wise comparisons were used using Wilcoxon rank sum test with

holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 8-The p-values from the pair-wise test

Methods	A	B	C
B	0.8090	-	-
C	0.0887	0.0693	-
D	0.4136	0.4655	0.0064

Therefore the results showed that with 90% confidence interval that group C is significantly different from all others. *Hence among those who scored low level of emerging waste, improvising by 'coming up with new ideas relevant to current standard operating procedures' is considered the most efficient one.*

6.13. Studying what type of uncertainties are more frequently present while improvising

Question 8 in the survey included several statements each referring to a different form of uncertainties that the improviser would have to deal with while improvising in construction. These statements were derived from the ABC model that was previously discussed in the previous chapters. The four types of uncertainties studied are:

A. It is hard to recognize the need for improvisation
B. The methods of improvisation needed to resolve the situation and reach the goals are unclear
C. Goals are ill-defined and vague

D. The environment is rapidly changing and it is difficult to keep data up to date.

An ANOVA test can be performed in order to study which one of these uncertainties is most frequently used. The distribution of the collected data relative to each one of the four types of uncertainties is shown in the box plot below. The type D of uncertainties has the highest rank.

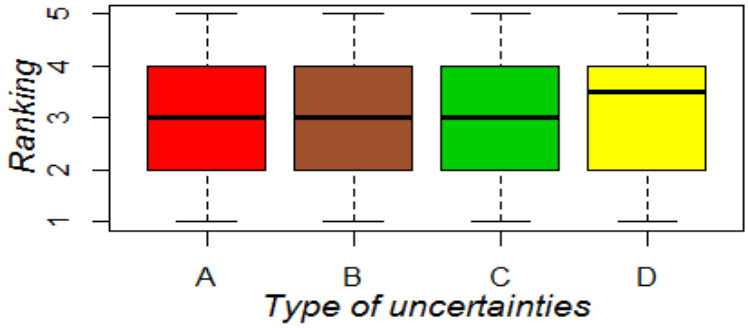

Figure 27-Ranking of the four different types of uncertainties

The following p-values were obtained after running Shapiro test:

1- Uncertainty A ➔ p-value= 3.757e-07

2- Uncertainty B ➔ p-value= 2.362e-07

3- Uncertainty C ➔ p-value= 6.984e-08

4- Uncertainty D ➔ p-value= 8.942e-08

Thus normality was rejected in the four groups. Furthermore the Kruskal Wallis rank sum test was used and the obtained p-value=0.001235. Hence with 90% confidence level the null hypothesis that all of the four groups are the same was rejected. In order to identify the group that is significantly different from the others

pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 9-The p-values from the pair-wise t-test

Uncertainties	A	B	C
B	0.0499	-	-
C	0.6279	0.2567	-
D	0.0017	0.4454	0.0300

Therefore the author concluded with 90% confidence interval that group D is significantly different from groups A &C but not B. In addition, B is significantly different from A. By examining the medians of the four groups, the author may conclude that *the improviser is most frequently faced by a fast changing environment, however he also struggles with the fact that the methods needed to resolve the situation and reach the goals are unclear.*

6.14. Studying whether consensus is gathered before executing the improvised decision

Question 10 in the survey included three statements. One stating that consensus is gathered between managers only before executing the improvised decision, the second affirming that consensus is gathered between all team members and finally the third stating that no consensus is gathered. An ANOVA test can be performed in order to study which of these of these statements is considered true. The distribution of the collected data relative to each one of the three groups is shown in the box plot below.

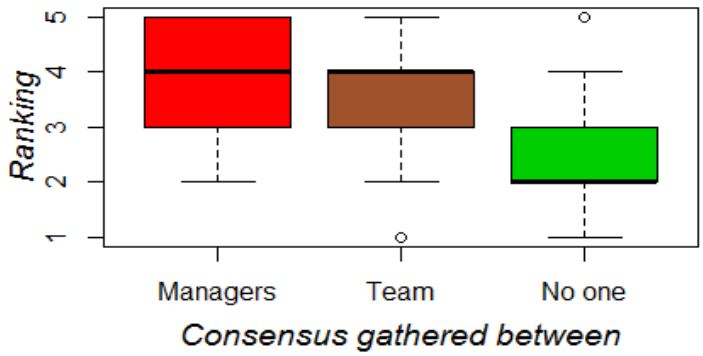

Figure 28-The gathered consensus

Shapiro test was used and obtained the following p-values:

1- Consensus is gathered between managers only➔ p-value= 7.262e-10
2- Consensus is gathered between all team members➔ p-value= 7.951e-08
3- No consensus is gathered➔ p-value= 3.17e-08

Thus enough evidence is present to reject normality in the three groups. Hence the Kruskal-Wallis rank sum test was used and the obtained p-value=2.2e-16. Therefore with 90% confidence level the null hypothesis that all of the three groups are the same was rejected. In order to identify the group that is significantly different from the others pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 10-The p-values from the pair-wise t-test

Groups	A	B
B	0.0059	-
C	2e-16	1.2e-09

Therefore the author concluded with 90% confidence interval that all groups are significantly different. *Hence before executing the improvised decision, consensus is most frequently gathered between managers only.*

6.15. Studying if the improviser considers different alternatives while improvising

Question 9 in the survey included two opposite statements, one stating that different alternatives are assessed before making the decision and the other considering that the first solution encountered is executed. In order to study which statement is considered true, a t-test was performed using R software. Shapiro test was used and the following p-values were obtained: the different alternatives group has a p-value= 2.511e-12 and the one alternative group has a p-value = 2.126e-08. Hence normality was rejected in both cases. Then the non-parametric Mann-Whitney test was used with the "two sided" alternative option, but after testing equal variances a p-vlaue=0.0284 was obtained. Thus paired wilcoxon signed rank test was used. Pairing is possible in such a case since each interviewed individual answers both questions simultaneously. The obtained p-value = 1.645e-13. *Hence with 95% confidence level the author concluded that different alternatives are discussed before making the decision.* The box plot below shows the variation of the ranking of the two statements in question 9.

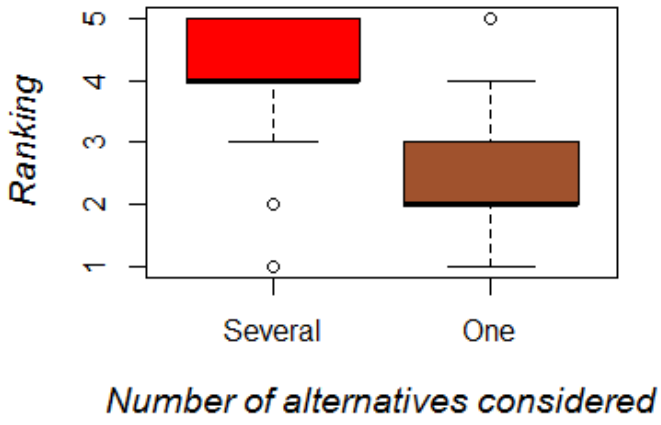

Figure 29-Alternatives discussed before improvising

6.16. Studying the identity of the improviser

Here three different categorizes of improvisers were distinguished:

1- Managers

2- Workers who are given information about task status

3- Teams that work collaboratively to share experience and improvise better

An ANOVA test can be performed in order to study which one of these three categorizes practices improvisation more often. The distribution of the collected data relative to each one of the three groups is shown in the box plot below.

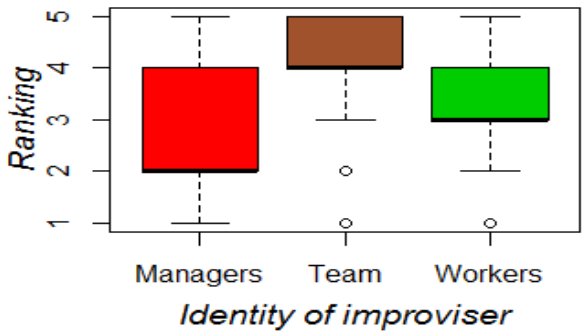

Figure 30-The different categories of the identity of the improviser

Shapiro test was used and the following p-values were obtained:

1- Managers➔ p-value= 4.934e-08

2- Workers➔ p-value= 4.331e-08

3- Team➔ p-value= 3.7e-11

Thus normality was rejected in the three groups. Hence the Kruskal-Wallis rank sum test was used and the obtained p-value=4.385e-15. Hence with 90% confidence level the null hypothesis that all of the three groups are the same was rejected. In order to identify the group that is significantly different from the others e used pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 11-The p-values from the pair-wise t-test

Improviser	M	T
T	3.1e-13	-
W	0.00026	2.6e-08

Therefore the author concluded with 90% confidence interval that all groups are significantly different. *Hence teams frequently work collaboratively in order to improvise. Furthermore, workers are considered to practice improvisation more than managers.*

6.17. Studying what type of training is considered to best enhance the practice of improvisation among individuals who scored low level of emerging waste

Four different types of training are suggested in question 12:

A- Training to know wide set of routines and procedures very well

B- Training to learn high level concepts rather than procedures

C- Training to enhance the worker's ability to generate different alternatives

D- Training to improve the worker's ability to handle pressure

In order to study which type of training is considered effective, the data gathered from individuals who scored low level of emergent waste was only examined. 73 respondents out of the 120 interviewed individuals scored below 0.2 on the level of emerging waste. Their responds to question 12 were examined to study which type of training is considered most effective. In order to achieve that, an ANOVA test can be performed. The distribution of the collected data relative to each one of the four types of training is shown in the box plot below.

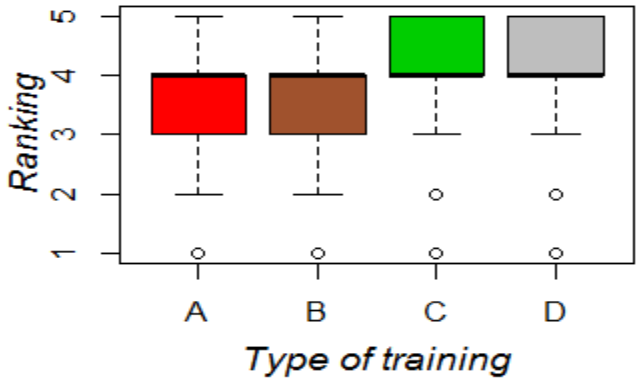

Figure 31-Ranking of the efficiency of the four different types of training

Shapiro test was used and obtained the following p-values:

1- Training A ➔ p-value= 2.147e-06

2- Training B ➔ p-value= 3.563e-0

3- Training C ➔ p-value= 3.603e-08

4- Training D ➔ p-value= 8.408e-08

Thus normality was rejected in the four groups. Hence the Kruskal-Wallis rank sum test was used and the obtained p-value= 0.1063. Hence with 90% confidence level, the null hypothesis that all of the four groups are the same was rejected. But on the other hand, the author noticed that all four types of training are ranking 3 and above. In order to study if this statement is statically significant a one sample sign t-test was performed that checks if the means of the four groups of data is greater than 3. The p-values obtained are as follows:

A- P-value= 1.12378e-05

B- P-value= 2.80705e-06

C- P-value= 1.067921e-10

D- P-value= 2.344092e-08

Hence among those who scored low level of emerging waste, the four suggested types of training are considered able to enhance the practice of improvisation.

6.18. Studying what types of preparation are frequently practiced

Here nine different steps of preparation derived from the decision making process discussed previously were distinguished:

A- Recall information from past personal experience

B- Ask the team to help by sharing experience and learning that was not formally documented in the past

C- Ask for help from another organizations that would be willing to share their knowledge

D- Refer to standard operating procedures

E- Pass the problem to managers without trying to solve it

F- Break out from conventional methods and think outside the box

G- Hire a new member that has experience in solving similar problems

H- Benchmark the working procedures of leading organizations in the industry

I- Try to redefine the problem to fit available solutions

An ANOVA test can be performed in order to study which ones of these nine steps are more frequently performed before improvising. The distribution of the collected data relative to each one of these groups is shown in the box plot below.

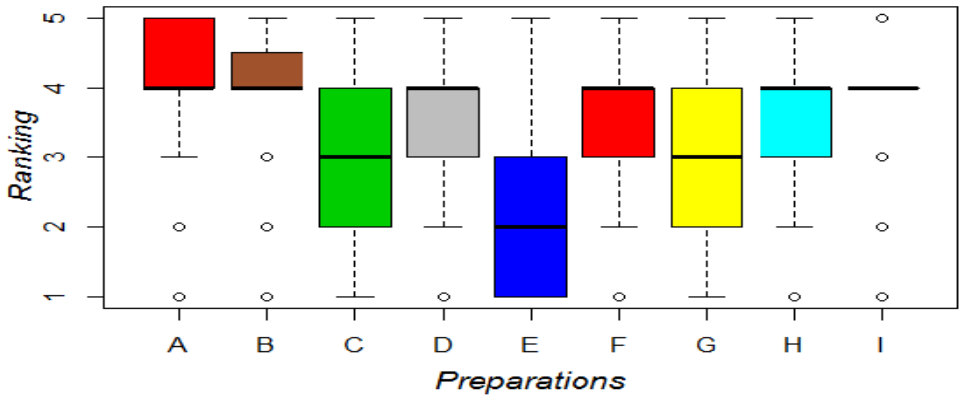

Figure 32-The different preparation steps

Shapiro test was used and the following p-values were obtained:

1- P-value = 7.903e-14

2- P-value = 1.825e-12

3- P-value = 6.773e-08

4- P-value = 6.592e-09

5- P-value = 3.21e-10

6- P-value = 8.619e-09

7- P-value = 1.061e-06

8- P-value = 4.903e-08

9- P-value = 3.227e-12

Thus normality was rejected in the nine groups. Hence the Kruskal-Wallis rank sum test was and the obtained p-value < 2.2e-16. Hence with 90% confidence level the null hypothesis that all of the nine groups are the same was rejected. In order to identify the group that is significantly different from the others, pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 12-The p-values from the pair-wise test

Steps	A	B	C	D	E	F	G	H
B	0.07991	-	-	-	-	-	-	-
C	3.6e-15	1.1e-09	-	-	-	-	-	-
D	5.2e-06	0.04824	6.8e-05	-	-	-	-	-
E	< 2e-16	< 2e-16	6.8e-05	2e-16	-	-	-	-
F	6.2e-05	0.15556	1.4e-05	1.00	< 2e-16	-	-	-
G	< 2e-16	3.2e-12	1.00	1.5e-06	7.3e-06	2.6e-07	-	-
H	3.0e-08	0.00148	0.00369	0.95621	1.6e-15	0.54593	0.0002	-
I	0.00675	1.00	9.3e-10	0.11313	< 2e-16	0.34736	9.5e-13	0.00364

Therefore the author concluded with 90% confidence interval that improvisers most frequently recall information from past personal experience before improvising. Furthermore the author concluded that improvisers seldom pass the problem to managers without trying to solve it.

6.19. Studying what personal characteristic is considered important to increase the chances of successful improvisation among those who scored low level of emerging waste

In question 18 in the survey the author only choose to focus on the following personal characteristics:

A- Reacting well to time pressure

B- Experience

C- Taking risk

D- Open to experimenting

E- Ability to communicate with others

In order to study which of these characteristics could increase the improviser's chances of successful improvisation, the data gathered from individuals who scored low level of emergent waste was only examined. 73 respondents out of the 120 scored below 0.2 on the level of emerging waste. The distribution of the collected data relative to each one of the five groups is shown in the box plot below.

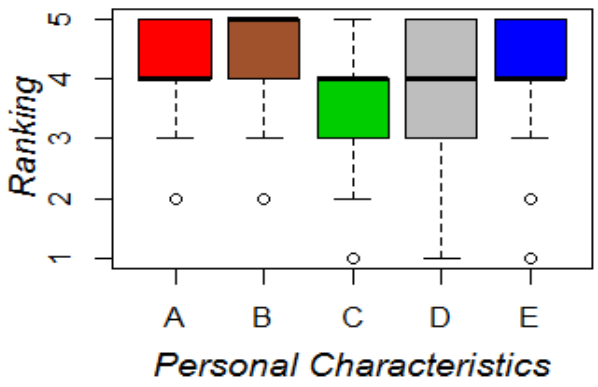

Figure 33-Ranking of the efficiency of the five personal characteristics

An ANOVA test can be used to identify which characteristic is considered more important to enhance the improviser's chance of successful improvisation. Shapiro test was used and the following p-values were obtained:

A- p-value= 1.048e-09

B- p-value= 8.54e-11

C- p-value= 1.916e-06

D- p-value= 1.659e-07

E- p-value= 8.426e-10

Thus normality was rejected in the five groups. Hence the Kruskal-Wallis rank sum test was used and the obtained p-value=1.739e-08. Hence with 90% confidence level, the null hypothesis that all of the five groups are the same was rejected. In order to identify the group that is significantly different from the others pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 13-The p-values from the pair-wise test

Personal	A	B	C	D
B	0.763	-	-	-
C	2.2e-05	1.3e-06	-	-
D	0.028	0.002	0.372	-
E	0.938	0.938	7.2e-05	0.028

Thus with 90% confidence level the author concluded that these groups are significantly different:

1- *A&C ➔ Reacting well to time pressure is considered more important than taking risk*
2- *B&C ➔ Experience is considered more important than taking risk*
3- *A&D ➔ Reacting well to time pressure is considered more important than being open to experimenting*
4- *B&D ➔Experience is considered more important than being open to experimenting*
5- *C&E ➔ having good communication skills is considered more important than taking risk*
6- *D&E ➔ having good communication skills is considered more important than being open to experimenting*

On the other hand, all five characteristics are ranking 3 and above. In order to study if this statement is statically significant, a non-parametric one sample sign t-test was used that checks if the means of the five groups of data is greater than 3. The p-values obtained are as follows:

A- P-value= 4.024558e-16

B- P-value= 1.129929e-13

C- P-value= 9.732503e-09

D- P-value= 6.057629e-08

E- P-value= 7.569163e-10

Hence among those who scored low level of emerging waste, the five suggested personal characteristics are considered important to improve the improviser's chances of sound improvisation

6.20. Studying whether improvisers assess the risk of failure before improvising

In order to study if improvisers assess the risk of failure before improvising, a one sample t-test could be performed that compares the mean of the responses to question 15 in the survey to 3. Shapiro test was used and the obtained p-value= 1.35e-11, hence normality of data was rejected and consequently a non-parametric one sample sign t-test must be used. After removing the responds that are equal to three, each response is given a + sign if it is greater than 3 and – sign if it less than 3. Then the – signs are counted and their relative probability is calculated. The obtained p value is 6.994093e-13. *Hence with 90% confidence interval improvisers frequently assess the risk of failure before improvising.*

6.21. Studying whether improvisers document the results of their improvisation

In order to study if improvisers document the results of their improvisation, a one sample t-test that compares the mean of the responses to question 16 in the survey to 3 can be used. Shapiro test was used to study normality and the obtained p-value= 1.594e-11, hence normality of data was rejected and consequently a non-parametric one sample sign t-test must be used. After removing the responds that are equal to three, each response is given a + sign if it is greater than 3 and – sign if it less than 3. Then the – signs are counted and their relative probability is calculated.

The obtained p value is 8. 293858e-11. *Hence improvisers frequently document the results of their improvisation.*

6.22. Studying what characteristics of the organization are considered important to increase the chances of successful improvisation among those who scored low level of emerging waste

In question 19 in the survey the author only choose to focus on the following qualities and practices of the organization:

A- Empowers the employees

B- Allows employees to brake some regulations and rules when necessary

C- Allows experimenting in order to find suitable solution

D- Tolerates non optimal solutions

E- Defines the roles and responsibilities for each employee

F- Practices good planning procedures

G- Stores learning and keeps records

H- Allows giving authority to the employee with more experience in the relevant field

In order to study which of these characteristics could increase the improviser's chances of successful improvisation, the author only examined the data gathered from individuals who scored low level of emergent waste. 73 respondents out of the 120 scored below 0.2 on the level of emerging waste. The distribution of the collected data relative to each one of these groups is shown in the box plot below.

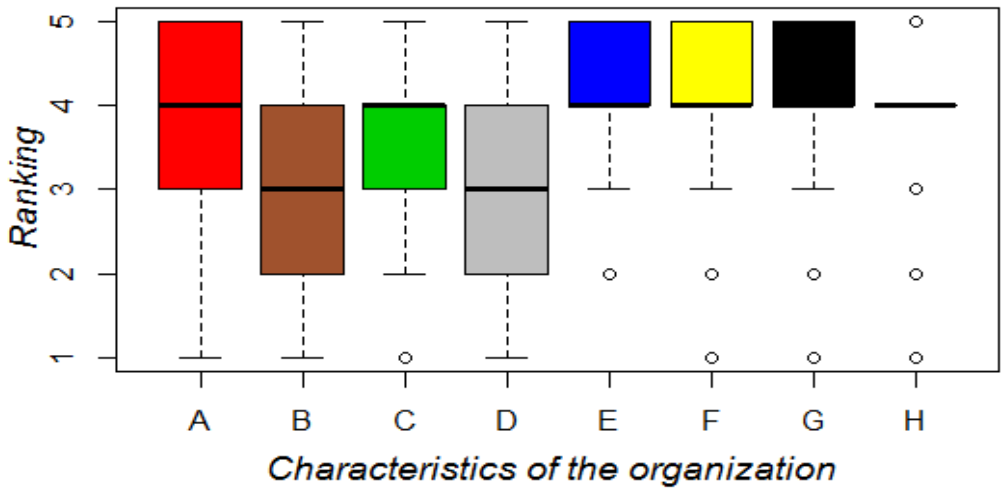

Figure 34-Ranking of the efficiency of the eight characteristics of organizations

An ANOVA test van be used to identify which characteristic is considered more important to enhance the improviser's chance of successful improvisation. Shapiro test was used and the following p-values were obtained:

A- p-value = 6.657e-08

B- p-value = 7.251e-05

C- p-value = 2.188e-07

D- p-value = 0.0001168

E- p-value = 2.051e-08

F- p-value = 1.803e-09

G- p-value = 1.932e-09

H- p-value = 2.875e-09

Thus normality was rejected in the eight groups. Hence the Kruskal-Wallis rank sum test was used and the obtained p-value=2.2e-16. Thus with 90% confidence level, the null hypothesis that all of the eight groups are the same was rejected. In order to identify the group that is significantly different from the others pair-wise comparisons were performed using Wilcoxon rank sum test with holm as the p-value adjustment method. The obtained p-values are shown in the table below:

Table 14-The p-values from the pair-wise test

Characteristics	A	B	C	D	E	F	G
B	8.2e-07	-	-	-	-	-	-
C	0.02841	0.04052	-	-	-	-	-
D	3.5e-07	1.00	0.01968	-	-	-	-
E	1.00	1.1e-09	0.00383	2.2e-10	-	-	-
F	1.00	6.4e-10	0.00056	1.6e-10	1.00	-	-
G	1.00	7.1e-09	0.00354	1.7e-09	1.00	1.00	-
H	1.00	1.1e-07	0.05944	2.3e-08	1.00	0.85	1.00

Thus with 90% confidence level the author concluded that these groups are significantly different:

1- *A&B ➔ Empowering the employees is considered more important allowing them to brake some regulations and rules when necessary*
2- *A&C ➔ Empowering the employees is considered more important allowing them to experiment in order to find suitable solution*
3- *A&D ➔ Empowering the employees is considered more important than tolerating non optimal solutions*
4- *B&C ➔Allowing employees to experiment in order to find suitable solution is considered more important than allowing them to brake some regulations and rules when necessary*
5- *B&E ➔Defining the roles and responsibilities for each employee is considered more important than allowing them to brake some regulations and rules when necessary*
6- *B&F ➔Practicing good planning procedures is considered more important than allowing employees to brake some regulations and rules when necessary*
7- *B&G ➔Storing learning and keeps records procedures is considered more important than allowing employees to brake some regulations and rules when necessary*
8- *B&H ➔Allowing authority mitigation to the employee with more experience in the relevant field is considered more important than allowing employees to brake some regulations and rules when necessary*

9- *C&D ➔Allowing employees to experiment in order to find suitable solution is considered more important than tolerating non optimal solutions*

10- *C&E ➔Defining the roles and responsibilities for each employee is considered more important than allowing employees to experiment in order to find suitable solution*

11- *C&F ➔Practicing good planning procedures is considered more important than allowing employees to experiment in order to find suitable solution*

12- *C&G ➔Storing learning and keeping records is considered more important than allowing employees to experiment in order to find suitable solution*

13- *C&H ➔ Allowing authority mitigation to the employee with more experience in the relevant field is considered more important than allowing employees to experiment in order to find suitable solution*

14- *D&E ➔Defining the roles and responsibilities for each employee is considered more important than tolerating non optimal solutions*

15- *D&F ➔Practicing good planning procedures is considered more important than tolerating non optimal solutions*

16- *D&G ➔Storing learning and keeping records is considered more important than tolerating non optimal solutions*

17- *D&H ➔ Allowing authority mitigation to the employee with more experience in the relevant field is considered more important than tolerating non optimal solutions*

On the other hand, the author noticed that all eight characteristics are ranking 3 and above. In order to study if this statement is statically significant a non-

parametric one sample sign t-test that checks if the means of the 8 groups of data is greater than 3 was performed. The p-values obtained are as follows:

A- P-value= 2.168192e-07

B- P-value= 0.8041985

C- P-value= 0.0001776406

D- P-value= 0.6742061

E- P-value= 1.554312e-15

F- P-value= 8.489841e-13

G- P-value=4.861481e-11

H- P-value=5.504028e-12

Hence among those who scored low level of emerging waste, all suggested characteristics of the organization, except for allowing employees to brake some regulations and rules when necessary and tolerating non optimal solutions, are considered important to improve the improviser's chances of sound improvisation.

The R code used in the data analysis is attached in the appendix for further information.

To sum up the data analysis performed were summarized in the table below:

Table 15- Summary for all data analysis

Test	Normality of groups		Statistical test used -1	P-value	Statistical test used -2	Results
	Yes	No				
Most frequent cause		X	Kruskal-Wallis rank sum test	1.30E-10	Wilcoxon rank sum test	Significant difference between all groups except the 2nd and the 3rd
Influence of experience on the emerging level of waste		X	Kruskal-Wallis rank sum test	0.07	Wilcoxon rank sum test	Significant difference between 2nd and 3rd group
Influence of experience on the percent of task completed		X	Mann-Whitney test	0.0004	-	Significant difference between groups
Influence of education on the emerging level of waste	X		t-test	0.36	-	No significant difference between groups
Influence of education on the percent of task completed		X	Mann-Whitney test	1	-	No significant difference between groups
Influence of type of organization on the level of emerging waste	X		t-test	0.0046	-	Significant difference between groups
Influence of type of organization on the % of task completed		X	Mann-Whitney test	0.475	-	No significant difference between groups
The most frequently used method		X	Kruskal-Wallis rank sum test	3.00E-12	Wilcoxon rank sum test	Group C is significant different from A & B
Which method is considered most effective among individuals who scored low level of emerging waste		X	Kruskal-Wallis rank sum test	0.005	Wilcoxon rank sum test	Significant difference betweenall groups except A & B
What type of uncertainties are more frequently present while improvising		X	Kruskal-Wallis rank sum test	0.001	Wilcoxon rank sum test	Group D is significantly different from groups A &C but not B.
Are consensus gathered before executing the improvised decision		X	Kruskal-Wallis rank sum test	2.20E-16	Wilcoxon rank sum test	Significant difference between groups

Does the improviser considers different alternatives while improvising	X	Paired wilcoxon signed rank test	1.65E-13	-	Significant difference between groups
Identity of the improviser	X	Kruskal-Wallis rank sum test	4.39E-15	Wilcoxon rank sum test	Significant difference between groups
What type of training is considered to best enhance the practice of improvisation among individuals who scored low level of emerging waste	X	Kruskal-Wallis rank sum test	0.1063	one sample sign t-test	The means are significantly different than 3
What types of preparation are frequently practiced	X	Kruskal-Wallis rank sum test	< 2.2e-16	Wilcoxon rank sum test	Groups A & E are significantly different than all others
Do improvisers assess the risk of failure before improvising	X	one sample sign t-test	7.00E-13	-	The mean is significantly different than 3
Do improvisers document the results of their improvisation	X	one sample sign t-test	8. 3E-11	-	The mean is significantly different than 3
What personal characteristic is considered to increase the chances of successful improvisation among those who scored low level of emerging waste	X	one sample sign t-test	4.0E-16; 1.13E-13; 9.7E-09; 6.06E-08; 7.6E-10	-	The means are significantly different than 3
What characteristics of the organization are considered to increase the chances of successful improvisation among those who scored low level of emerging waste	X	one sample sign t-test	2.2E-07; 0.8; 0.0002; 0.7; 1.6E-15; 8.5E-13; 4.91E-11; 5.5E-12	-	The means are significantly different than 3

CHAPTER 7

CONCLUSIONS

It is commonly known that the levels of uncertainties are considerably high in construction. The Last planner system was devised to mitigate foreseen uncertainties and manage them (Hamzeh, 2009). But a complex environment necessitates improvisation as a complementary process for planning since it has the potential to help organization subdue unplanned incidents into their own good will and protect themselves, at least partially, from unavoidable situations (Cunha et al, 1999). Even though improvisation is present in the construction industry, very few scholars have studied it. The purpose of this study is to provide a better understanding for improvisation in construction, realize the factors contributing in sound improvisation and fatherly model the process of improvisation in construction to guide the specialists' decisions-making process towards attaining the desired improvisational outcomes.

In order to achieve that, first an ABC model was proposed to summarize all possible stimulants, behaviors and consequences of improvisation in the construction industry. Then a survey was developed to gather the necessary data to answer 21 research questions which were considered interesting. Structural interviews were performed to collect the necessary data for this study and afterwards the collected data was analyzed. At 90% confidence interval the following results were obtained:

I. Regarding the stimulants section in the developed ABC model the author concluded that the most frequent cause for improvisation in the construction filed is ‘Failure in execution’ and ‘seeing opportunities to improve ready and sound task’. The identification of missing prerequisites is less frequent than the previous 2 causes. And finally poor definition of scoop of work can be considered as the least frequent cause.

II. Regarding the behaviors section in the ABC model the author concluded that:

    i. The most frequently used method is improvising by ‘coming up with new ideas relevant to current standard operating procedures’. Improvising by ‘giving new definitions for planned procedures’ and improvising by ‘combining resources in a different way than what was previously planned’, comes next in line and are less frequently used than method mentioned before. On the other hand, improvising by ‘executing entirely novel procedures that don’t resemble any previous actions’ is the used the least.

    ii. Among those who scored low on the level of emerging waste, improvising by ‘coming up with new ideas relevant to current standard operating procedures’ is considered the most efficient method.

    iii. The improviser is most frequently faced by a fast changing environment; however he also struggles with the fact that the methods needed to resolve the situation and reach the goals are unclear.

iv. Frequently, teams work collaboratively in order to improvise. Furthermore workers are considered to practice improvisation more than managers.

v. Among those who scored low on the level of emerging waste, the following four types of training are considered able to enhance the practice of improvisation:

- Training to know wide set of routines and procedures very well
- Training to learn high level concepts rather than procedures
- Training to enhance the worker's ability to generate different alternatives
- Training to improve the worker's ability to handle pressure

As for the developed decision making flow chart, the author concluded the following:

i. Before executing the improvised decision, consensus is most frequently gathered between managers only

ii. Different alternatives are discussed before making the decision.

iii. Frequently, improvisers recall information from past personal experience before improvising. Furthermore, improvisers seldom pass the problem to their managers without trying to solve it.

iv. Frequently, improvisers assess the risk of failure before improvising.

v. Frequently, improvisers document the results of their improvisation.

III. Regarding the Consequences section in the ABC model the author concluded that the following factors have a significant effect on the two outcomes indexes: the level of emerging waste and the percent of task completed:

   i. Experience, where Individuals with experience of more than 10 years, practice improvisation with higher percent of task completed and lower level of emergent waste than those having less than 10 years of experience.
   ii. The type of organization, where it shows significant effect on the level of emerging waste when the individual practices improvisation. Improvisation in an empowering organization tends to have a lower level of emergent waste. On the other hand, type of organization fails to show any significant effect on the percent of task completed when an individual practices improvisation.

Furthermore, the following factors fail to show any significant effect on the two outcome indexes: the level of emerging waste and the percent of task completed:

   i. Education
   ii. The degree of novelty of the input of improvisation

Moreover, among those who scored low on the level of emerging waste, the following suggested personal characteristics are considered important to improve the improviser's chances of sound improvisation:

i. Reacting well to time pressure
ii. Experience
iii. Taking risk
iv. Open to experimenting
v. Ability to communicate with others

Similarly, among those who scored low on the level of emerging waste, the following characteristics of the organization are considered important to improve the improviser's chances of sound improvisation:

i. Empowers the employees
ii. Allows experimenting in order to find suitable solution
iii. Defines the roles and responsibilities for each employee
iv. Practices good planning procedures
v. Stores learning and keeps records
vi. Allows giving authority to the employee with more experience in the relevant field

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APPENDIX

1. Level of Emerging Waste

I.D	L.w
1	0.56104477
2	0.141933194
3	-0.533087036
4	-1.606133369
5	-0.356794399
6	0.085699612
7	-0.473789257
8	0.776916731
9	-0.219530557
10	-0.631085816
11	-0.149516621
12	-0.287388524
13	-0.082339943
14	-0.872771014
15	-1.299055744
16	-0.745993716
17	0.288597819
18	1.265617271
19	-1.780585252
20	0.900887655
21	0.444335881
22	0.047415562
23	0.670027342
24	0.976597391
25	-0.242226401
26	0.582536138
27	-0.006757901
28	1.150529433
29	1.434941126
30	-0.09702294
31	-1.044450994
32	-1.042482169
33	-1.356849597
34	-0.887877002
35	-0.806500054
36	-1.082395141
37	-0.442573096
38	0.00436299
39	0.382768763
40	-0.414667705

ID	L.w
41	-1.381605561
42	0.529750801
43	-0.038023233
44	-0.0801525
45	0.75664711
46	1.070725495
47	1.336329669
48	0.992877942
49	-1.643358024
50	1.648008779
51	0.393646901
52	0.534481963
53	1.275054668
54	-0.872808636
55	-1.520394438
56	-0.178694995
57	0.129336595
58	1.186043646
59	-0.112130994
60	0.692686572
61	-1.780585252
62	0.994433366
63	1.228769133
64	0.071214011
65	-0.028831401
66	-0.560464044
67	0.098537008
68	1.250587585
69	-0.411307764
70	0.570485879
71	0.139664232
72	-1.780585252
73	-1.346568349
74	-0.130517469
75	0.347731551
76	-0.588441848
77	-1.276478034
78	-1.002186616
79	0.939490869
80	-1.20409496

ID	L.w
81	-0.703727273
82	-0.342065935
83	1.59043047
84	1.966570993
85	0.094256543
86	-0.658911754
87	-0.152414366
88	-0.256542548
89	-0.982090785
90	0.57186759
91	-0.036097247
92	0.120648973
93	0.709013298
94	0.188676765
95	0.529682665
96	0.394350502
97	0.394350502
98	1.59043047
99	-1.643439543
100	1.878946402
101	-0.952462773
102	-0.485802902
103	0.236854291
104	0.352964972
105	0.945281115
106	-0.160227
107	1.750074437
108	0.560705506
109	-0.094960416
110	-1.455890186
111	-0.745993716
112	0.551890191
113	-0.03621538
114	0.315151698
115	-0.953095716
116	-0.15447689
117	1.382733337
118	0.132532411
119	1.039539994
120	-0.984150534

2. R-Code

#Explaratory factor analysis

```
wants <- c("GPArotation", "mvtnorm", "polycor", "psych")

has   <- wants %in% rownames(installed.packages())

if(any(!has)) install.packages(wants[!has])

A=read.csv("C:/Users/lg/Desktop/final R code/Q6.csv", header=T)

d.A=data.frame(A)

d.B=data.matrix(A)

library(psych)

fap <- fa.parallel(d.B,cor="poly")# parallel analysis for ordinal data

 # as we see from the plot that one we can use one factor to describe the data

library(psych)

faPC <- fa.poly(d.A, nfactors=1, n.obs=120, rotate="oblimin",fm="pa",scores="regression",
oblique.scores=TRUE,cor="poly")

#Exploratory Factor analysis using Principal Axis factoring, using oblique rotation, and
based on

#polychoric correlation matrix

faPC

l.w=faPC$scores

#Visualizing loadings

fa.diagram(faPC)

factor.plot(faPC, cut=0.5)

hist(l.w$scores,col="red", main="The emerging level of waste")
```

#Studying the causes

```
C=read.csv("C:/Users/lg/Desktop/final R code/causes.csv", header=T)

C1=read.csv("C:/Users/lg/Desktop/final R code/causes1.csv", header=T)

boxplot(C1$count ~ C1$cause,col = c("red","sienna",99,15),at = c(1,2,3,4),las = 2,names =
c("Missing prerequisites","Poor task definition","Opportunity to improve","Failure in
execution"))

mtext("Ranking", side = 2,line=2, cex =1, font = 3)

shapiro.test(C[,1])

shapiro.test(C[,2])

shapiro.test(C[,3])

shapiro.test(C[,4])

C=data.frame(C)

#we need to use non-parametric tests

kruskal.test(C)#we reject that the three groups are the same with 90% confidence level

pairwise.wilcox.test(C1[,2], C1[,1],p.adj="holm")#group 3 & 4 is significantly different than
groups 1 and 2
```

#Studying the influence of experience 1

```
E=read.csv("C:/Users/lg/Desktop/final R code/exper.csv", header=T)

E[,1]=as.factor(E[,1])

boxplot(E$l.w ~ E$exp,col = c("red","sienna","palevioletred1"),at = c(1,2,3),names = c("<5
years",">5&<10 years",">10 years"))

mtext("Level of emerging waste", side = 2,line=3, cex =1.2, font = 3)

mtext("Experience", side = 1,line=3, cex =1.2, font = 3)

bartlett.test(E[,2], as.factor(E[,1]))#we reject eaual variances
```

#we need to use non-parametric tests

E1=read.csv("C:/Users/lg/Desktop/final R code/Exp.csv", header=T)

E1=data.frame(E1)

kruskal.test(E1)#we reject that the three groups are the same with 90% confidence level

pairwise.wilcox.test(E[,2], E[,1],p.adj="holm")#group 3 is significantly different than groups 1 and 2

#Studying the influence of experience 2

ex=read.csv("C:/Users/lg/Desktop/final R code/Exp'.csv", header=T)

shapiro.test(ex[,1])#reject normality

shapiro.test(ex[,2])# reject normality

var.test(ex[,1],ex[,2])#fail to reject equal variance at 95% CONFIDENCE LEVEL

wilcox.test(ex[,1],ex[,2], alternative="less")#reject H0

ex1=read.csv("C:/Users/lg/Desktop/final R code/Exp1'.csv", header=T)

boxplot(ex1$task.comp ~ ex1$exp,col = c("red","sienna"),at = c(1,2),names = c("<10 years",">10 years"))

mtext("Percent of task completed", side = 2,line=3, cex =1.2, font = 3)

mtext("Experience", side = 1,line=3, cex =1.2, font = 3)

#Studying the influence of education 1

ed=read.csv("C:/Users/lg/Desktop/final R code/Educ.csv", header=T)

#testing fo normality

shapiro.test(ed[,1])#cannot reject normality

shapiro.test(ed[,2])#cannot reject normality

var.test(ed[,1], ed[,2])#reject equal variances

```
t.test(ed[,1], ed[,2] , alternative = c("two.sided"), var.equal = FALSE, conf.level = 0.9)#fail to reject that the two groups are the same

ed1=read.csv("C:/Users/lg/Desktop/final R code/educat.csv", header=T)

boxplot(ed1$l.w ~ ed1$collar, col = c("red","sienna"),at = c(1,2),names = c("Blue collar","White collar"))

mtext("Level of emergent waste", side = 2,line=3, cex =1.2, font = 3)

mtext("Education", side = 1,line=3, cex =1.2, font = 3)
```

#Studying the influence of education 2

```
ed1=read.csv("C:/Users/lg/Desktop/final R code/Edu'.csv", header=T)

#testing fo normality

shapiro.test(ed1[,1])#reject normality

shapiro.test(ed1[,2])#reject normality

var.test(ed1[,1],ed1[,2])#fail to reject equal variance

wilcox.test(ed1[,1],ed1[,2], alternative="less")#fail to reject H0

ed2=read.csv("C:/Users/lg/Desktop/final R code/Edu1'.csv", header=T)

boxplot(ed2$task.comp ~ ed2$Educ, col = c("red","sienna"),at = c(1,2),names = c("Blue collar","White collar"))

mtext("Percent of task completed", side = 2,line=3, cex =1.2, font = 3)

mtext("Education", side = 1,line=3, cex =1.2, font = 3)
```

 # Studying the influence of type of organization 1

```
O=read.csv("C:/Users/lg/Desktop/final R code/org.csv", header=T)

shapiro.test(O[,1])#fail to reject normality

shapiro.test(O[,2])#fail to reject normality

var.test(O[,1], O[,2])#fail to reject equal variances
```

```
t.test(O[,1], O[,2] , alternative = c("two.sided"), var.equal = TRUE, conf.level = 0.9) # reject H0

O1=read.csv("C:/Users/lg/Desktop/final R code/org1.csv", header=T)

boxplot(O1$l.w ~ O1$org, col = c("red","sienna"),at = c(1,2),names = c("Knowing organization","Empowering organization"))

mtext("Level of emergent waste", side = 2,line=3, cex =1.2, font = 3)

mtext("Type of organization", side = 1,line=3, cex =1.2, font = 3)
```

 # Studying the influence of type of organization2

```
O2=read.csv("C:/Users/lg/Desktop/final R code/org'.csv", header=T)

shapiro.test(O2[,1])#reject normality

shapiro.test(O2[,2])#reject normality

var.test(O2[,1],O2[,2])#fail to reject equal variance

wilcox.test(O2[,1],O2[,2], alternative="two.sided")# reject H0

O3=read.csv("C:/Users/lg/Desktop/final R code/org1'.csv", header=T)

boxplot(O3$t.c ~ O3$org, col = c("red","sienna"),at = c(1,2),names = c("Knowing organization","Empowering organization"))

mtext("Percent of task completed", side = 2,line=3, cex =1.2, font = 3)

mtext("Type of organziation", side = 1,line=3, cex =1.2, font = 3)
```

 # Studying the influence of degree of novelty 1

```
N=read.csv("C:/Users/lg/Desktop/final R code/novelty.csv", header=T)

N[,1]=as.factor(N[,1])

boxplot(N$l.w ~ N$novelty,  col = c("red","sienna",30),at = c(1,2,3),names = c("Both New & Repat.","New","Repatative"))

mtext("Level of emerging waste", side = 2,line=3, cex =1.2, font = 3)
```

```
mtext("Novelty of input", side = 1,line=3, cex =1.2, font = 3)

N1=read.csv("C:/Users/lg/Desktop/final R code/l.w.novelty.csv", header=T)

shapiro.test(N1[,2])#fail to reject normality

shapiro.test(N1[,3])#fail to reject normality

var.test(N1[,2], N1[,3])#fail to reject equal variances

t.test(N1[,2], N1[,3] , alternative = c("two.sided"), var.equal = TRUE, conf.level = 0.9) # fail
to reject H0
```

 # Studying the influence of degree of novelty 1

```
N2=read.csv("C:/Users/lg/Desktop/final R code/t.c.novelty.csv", header=T)

shapiro.test(N2[,1])# reject normality

shapiro.test(N2[,2])#reject normality

var.test(N2[,1],N2[,2])#fail to reject equal variance

wilcox.test(N2[,1],N2[,2], alternative="two.sided")#fail to reject H0

N=read.csv("C:/Users/lg/Desktop/final R code/novelty.csv", header=T)

N[,1]=as.factor(N[,1])

boxplot(N$task.comp ~ N$novelty,  col = c("red","sienna",30),at = c(1,2,3),names = c("Both
New & Repat.","New","Repatative"))

mtext("Percent of task completed", side = 2,line=3, cex =1.2, font = 3)

mtext("Novelty of input", side = 1,line=3, cex =1.2, font = 3)
```

 # Studying the method used

```
M=read.csv("C:/Users/lg/Desktop/final R code/method used.csv", header=T)

M1=read.csv("C:/Users/lg/Desktop/final R code/method used1.csv", header=T)

boxplot(M1$count ~ M1$method,col = c("red","sienna",99,15),at = c(1,2,3,4),names =
c("A","B","C","D"))
```

```
mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Method used", side = 1,line=2, cex =1.2, font = 3)

shapiro.test(M[,1])#reject normality

shapiro.test(M[,2])#reject normality

shapiro.test(M[,3])#reject normality

shapiro.test(M[,4])#reject normality

M=data.frame(M)

#we need to use non-parametric tests

kruskal.test(M)#we reject that the groups are the same with 90% confidence level

pairwise.wilcox.test(M1[,2], M1[,1],p.adj="holm")
```

 # Studying the efficiency of the method used

```
T=read.csv("C:/Users/lg/Desktop/final R code/method'.csv", header=FALSE)

T1=read.csv("C:/Users/lg/Desktop/final R code/method2.csv", header=FALSE)

boxplot(T1[,2] ~ T1[,2],col = c("red","sienna",99,15),at = c(1,2,3,4),names =
c("A","B","C","D"))

mtext("Ranking", side = 2,line=3, cex =1.2, font = 3)

mtext("Method used", side = 1,line=3, cex =1.2, font = 3)

shapiro.test(T[,1])#reject normality

shapiro.test(T[,2])#reject normality

shapiro.test(T[,3])#reject normality

shapiro.test(T[,4])#reject normality

T=data.frame(T)

#we need to use non-parametric tests
```

```
kruskal.test(T)#we reject that the groups are the same with 90% confidence level

pairwise.wilcox.test(T1[,2], T1[,1],p.adj="holm")
```

#Studying uncertainties

```
R=read.csv("C:/Users/lg/Desktop/final R code/uncert.csv", header=F)

R1=read.csv("C:/Users/lg/Desktop/final R code/uncert1.csv", header=F)

boxplot(R1[,2] ~ R1[,1], col= c("red","sienna",99,15),at = c(1,2,3,4),names =
c("A","B","C","D"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Type of uncertainties", side = 1,line=2, cex =1.2, font = 3)

shapiro.test(R[,1])#reject normality

shapiro.test(R[,2])#reject normality

shapiro.test(R[,3])#reject normality

shapiro.test(R[,4])#reject normality

R=data.frame(R)

#we need to use non-parametric tests

kruskal.test(R)#we reject that the groups are the same with 90% confidence level

pairwise.wilcox.test(R1[,2], R1[,1],p.adj="holm")
```

#Studying whether consensus is gathered

```
CO=read.csv("C:/Users/lg/Desktop/final R code/cons.csv", header=FALSE)

CO1=read.csv("C:/Users/lg/Desktop/final R code/cons1.csv", header=FALSE)

boxplot(CO1[,2] ~ CO1[,1], col= c("red","sienna",99),at = c(1,2,3),names =
c("Managers","Team","No one"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)
```

```
mtext("Consensus gathered between", side = 1,line=2.5, cex =1.2, font = 3)
shapiro.test(CO[,1])#reject normality
shapiro.test(CO[,2])#reject normality
shapiro.test(CO[,3])#reject normality
CO=data.frame(CO)
#we need to use non-parametric tests
kruskal.test(CO)#we reject that the  groups are the same with 90% confidence level
pairwise.wilcox.test(CO1[,2], CO1[,1],p.adj="holm")
```

#Studying if different alternatives are assessed

```
A=read.csv("C:/Users/lg/Desktop/final R code/alt.csv", header=FALSE)
shapiro.test(A[,1])# reject normality
shapiro.test(A[,2])#reject normality
var.test(A[,1],A[,2])#fail to reject equal variance
wilcox.test(A[,1],A[,2], alternative="two.sided")#fail to reject H0
A1=read.csv("C:/Users/lg/Desktop/final R code/alt1.csv", header=False)
A1[,1]=as.factor(A1[,1])
boxplot(A1[,2]~ A1[,1],  col = c("red","sienna"),at = c(1,2),names = c("Several","One"))
mtext("Ranking", side = 2,line=3, cex =1.2, font = 3)
mtext("Number of alternatives considered", side = 1,line=3, cex =1.2, font = 3)
```

#Studying the identity of the improviser

```
I=read.csv("C:/Users/lg/Desktop/final R code/imp.csv", header=FALSE)
```

```
I1=read.csv("C:/Users/lg/Desktop/final R code/imp1.csv", header=FALSE)

boxplot(I1[,2] ~ I1[,1], col= c("red","sienna",99),at = c(1,2,3),names =
c("Managers","Team","Workers"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Identity of improviser", side = 1,line=2.5, cex =1.2, font = 3)

shapiro.test(I[,1])#reject normality

shapiro.test(I[,2])#reject normality

shapiro.test(I[,3])#reject normality

I=data.frame(I)#we need to use non-parametric tests

kruskal.test(I)#we reject that the  groups are the same with 90% confidence level

pairwise.wilcox.test(I1[,2], I1[,1],p.adj="holm")
```

#Studying the types of training

```
T=read.csv("C:/Users/lg/Desktop/final R code/train.csv", header=TRUE)

T1=read.csv("C:/Users/lg/Desktop/final R code/train1.csv", header=FALSE)

boxplot(T1[,2] ~ T1[,1], col= c("red","sienna",99,40),at = c(1,2,3,4),names =
c("A","B","C","D"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Type of training", side = 1,line=2.5, cex =1.2, font = 3)

shapiro.test(T[,1])#reject normality

shapiro.test(T[,2])#reject normality

shapiro.test(T[,3])#reject normality

shapiro.test(T[,4])#reject normality

T=data.frame(T)
```

```
#we need to use non-parametric tests

kruskal.test(T)#we reject that the  groups are the same with 90% confidence level

pairwise.wilcox.test(T1[,2], T1[,1],p.adj="holm")

pbinom(11,53,0.5, lower=F)

pbinom(9,50,0.5, lower=F)

pbinom(5,55,0.5, lower=F)

pbinom(8,56,0.5, lower=F)
```

#Studying the preparation steps

```
Pr=read.csv("C:/Users/lg/Desktop/final R code/q14.csv", header=TRUE)

Pr1=read.csv("C:/Users/lg/Desktop/final R code/q141.csv", header=FALSE)

boxplot(Pr1[,2] ~ Pr1[,1], col= c("red","sienna",99,40,60,50,56,80,81),at =
c(1,2,3,4,5,6,7,8,9),names = c("A","B","C","D","E","F","G","H","I"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Preparations", side = 1,line=2.5, cex =1.2, font = 3)

shapiro.test(Pr[,1])#reject normality

shapiro.test(Pr[,2])#reject normality

shapiro.test(Pr[,3])#reject normality

shapiro.test(Pr[,4])#reject normality

shapiro.test(Pr[,5])#reject normality

shapiro.test(Pr[,6])#reject normality

shapiro.test(Pr[,7])#reject normality

shapiro.test(Pr[,8])#reject normality

shapiro.test(Pr[,9])#reject normality
```

```
Pr=data.frame(Pr)

#we need to use non-parametric tests

kruskal.test(Pr)#we reject that the  groups are the same with 90% confidence level

pairwise.wilcox.test(Pr1[,2], Pr1[,1],p.adj="holm")
```

#Studying risk assement

```
Ri=read.csv("C:/Users/lg/Desktop/final R code/q15.csv", header=TRUE)

shapiro.test(Ri[,1])#reject normality

pbinom(15,98,0.5, lower=F)
```

#Studying documentation of results

```
D=read.csv("C:/Users/lg/Desktop/final R code/q16.csv", header=TRUE)

shapiro.test(D[,1])#reject normality

pbinom(19,101,0.5, lower=F)
```

#Studying the personal characteristics

```
P=read.csv("C:/Users/lg/Desktop/final R code/Q18.csv", header=TRUE)

P1=read.csv("C:/Users/lg/Desktop/final R code/Q181.csv", header=FALSE)

boxplot(P1[,2] ~ P1[,1], col= c("red","sienna",99,40,60),at = c(1,2,3,4,5),names =
c("A","B","C","D","E"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Personal Characteristics", side = 1,line=2.5, cex =1.2, font = 3)

shapiro.test(P[,1])#reject normality

shapiro.test(P[,2])#reject normality

shapiro.test(P[,3])#reject normality

shapiro.test(P[,4])#reject normality
```

```
shapiro.test(P[,5])#reject normality

P=data.frame(P)

#we need to use non-parametric tests

kruskal.test(P)#we reject that the  groups are the same with 90% confidence level

pairwise.wilcox.test(P1[,2], P1[,1],p.adj="holm")

pbinom(1,57,0.5, lower=F)

pbinom(3,58,0.5, lower=F)

pbinom(3,40,0.5, lower=F)

pbinom(7,51,0.5, lower=F)

pbinom(4,48,0.5, lower=F)
```

#Studying the characteristics of the organziation

```
OR=read.csv("C:/Users/lg/Desktop/final R code/Q19.csv", header=TRUE)

OR1=read.csv("C:/Users/lg/Desktop/final R code/Q191.csv", header=FALSE)

boxplot(OR1[,2] ~ OR1[,1], col= c("red","sienna",99,40,60,15,25,35),at =
c(1,2,3,4,5,6,7,8),names = c("A","B","C","D","E","F","G","H"))

mtext("Ranking", side = 2,line=2, cex =1.2, font = 3)

mtext("Characteristics of the organization ", side = 1,line=2.5, cex =1.2, font = 3)

shapiro.test(OR[,1])#reject normality

shapiro.test(OR[,2])#reject normality

shapiro.test(OR[,3])#reject normality

shapiro.test(OR[,4])#reject normality

shapiro.test(OR[,5])#reject normality

shapiro.test(OR[,6])#reject normality
```

```
shapiro.test(OR[,7])#reject normality

shapiro.test(OR[,8])#reject normality

OR=data.frame(OR)

#we need to use non-parametric tests

kruskal.test(OR)#we reject that the  groups are the same with 90% confidence level

pairwise.wilcox.test(OR1[,2], OR1[,1],p.adj="holm")

pbinom(9,55,0.5, lower=F)

pbinom(27,49,0.5, lower=F)

pbinom(14,55,0.5, lower=F)

pbinom(23,44,0.5, lower=F)

pbinom(1,55,0.5, lower=F)

pbinom(4,59,0.5, lower=F)

pbinom(6,60,0.5, lower=F)

pbinom(4,56,0.5, lower=F)
```

3. The English Survey

Q1. My position in the company: _____	
Q2. Number of employees: □ 1 to 19 □ 20 to 99 □ More than 100	**Q3**. My experience in the construction industry is: □ Below 5 years □ 5 to 10 years □ Over 10 years

Improvisation is creating or adapting new methods to resolve an emerging unplanned situation or to improve the current plan.

In the following questions: 1-Strongly disagree / 2-disagree / 3-neutral / 4-agree / 5-Strongly agree

Q4.Based on my own experience, I improvise when there is:

Missing prerequisites (information; space or limited access; labor; temporary facilities; safety; resources; weather)	Select 1 / 2 / 3 / 4 / 5
Inadequate definition of tasks, Poor definition of the scope of work	Select 1 / 2 / 3 / 4 / 5
Opportunities to improve ready and sound tasks	Select 1 / 2 / 3 / 4 / 5
New circumstances during execution	Select 1 / 2 / 3 / 4 / 5

Q5.Typically, I improvise in situations that are:

New and have never happened to any team member	Select 1 / 2 / 3 / 4 / 5
Of repetitive nature(such problems have occurred before to one or many of the team members)	Select 1 / 2 / 3 / 4 / 5

Q6. Based on my construction experience, improvisation leads to the following types of waste:

Increase in the usage of resources	Select 1 / 2 / 3 / 4 / 5
Increase in cost	Select 1 / 2 / 3 / 4 / 5
Increase in the duration of the project	Select 1 / 2 / 3 / 4 / 5
Decline of quality	Select 1 / 2 / 3 / 4 / 5
Decrease in safety performance	Select 1 / 2 / 3 / 4 / 5
Decrease in productivity	Select 1 / 2 / 3 / 4 / 5
Increase in the complexity of task controls	Select 1 / 2 / 3 / 4 / 5
Adverse effect on workers' morale	Select 1 / 2 / 3 / 4 / 5

Q7. When I improvise I use one or more of the following methods**:**

a. Improvise by giving new definition for planned procedures.	Select 1 / 2 / 3 / 4 / 5
b. Improvise by combining resources in a different way than what was previously planned (example using resources assigned for other tasks in order to execute current task).	Select 1 / 2 / 3 / 4 / 5
c. Improvise by coming up with new ideas relevant to current standard operating procedures	Select 1 / 2 / 3 / 4 / 5
d. Improvise by executing entirely novel procedures that don't resemble any previous actions	Select 1 / 2 / 3 / 4 / 5

Q7.1. Based on my own experience the most effective method from the above is: (Effective ➔Producing the least amount of waste while completing the required tasks)

a	Select 1 / 2 / 3 / 4 / 5
b	Select 1 / 2 / 3 / 4 / 5
c	Select 1 / 2 / 3 / 4 / 5
d	Select 1 / 2 / 3 / 4 / 5

Q8. When I improvise I face the following types of uncertainties:

It is hard to recognize the need for improvisation	Select 1 / 2 / 3 / 4 / 5
The methods of improvisation needed to resolve the situation and reach the goals are unclear	Select 1 / 2 / 3 / 4 / 5
Goals are ill-defined and vague	Select 1 / 2 / 3 / 4 / 5
The environment is rapidly changing and it is difficult to keep data up to date	Select 1 / 2 / 3 / 4 / 5

Q9. Before my team or I take the decision to improvise, the following is done:

Different alternatives are generated and assessed	Select 1 / 2 / 3 / 4 / 5
The first solution encountered is executed even if it not the optimum one (leading to more consumption of resources or to a decline in quality etc..)	Select 1 / 2 / 3 / 4 / 5

Q10. Before my team or I take action, the following is done:

Consensus is gathered between managers in the team responsible for executing the task	Select 1 / 2 / 3 / 4 / 5
Consensus is gathered between all team members	Select 1 / 2 / 3 / 4 / 5
No consensus is gathered	Select 1 / 2 / 3 / 4 / 5
All parties should agree upon improvisational action else it is abandoned	Select 1 / 2 / 3 / 4 / 5

Q11. According to my own experience**,** Improvisation ideas are usually suggested by:

Managers only	Select 1 / 2 / 3 / 4 / 5
Workers who are given information about task status	Select 1 / 2 / 3 / 4 / 5
Teams that work collaboratively to share experience and improvise better	Select 1 / 2 / 3 / 4 / 5

Q12. What type of training do you think can best enhance improvisation?

Training to know wide set of routines and procedures very well	Select 1 / 2 / 3 / 4 / 5
Training to learn high level concepts rather than procedures	Select 1 / 2 / 3 / 4 / 5
Training to enhance the worker's ability to generate different alternatives	Select 1 / 2 / 3 / 4 / 5
Training to improve the worker's ability to handle pressure	Select 1 / 2 / 3 / 4 / 5

Q13. The following statements apply to my work environment:

Employees are not encouraged to improve or rethink the way tasks are done.	Select 1 / 2 / 3 / 4 / 5
Regulations and standards should never be altered	Select 1 / 2 / 3 / 4 / 5
When mistakes occur, investigations are held to find who should be blamed	Select 1 / 2 / 3 / 4 / 5
Employees are encouraged to learn about their own jobs and divisions, but not about the relationships with other jobs and divisions.	Select 1 / 2 / 3 / 4 / 5
Managers inform employees about company's performance and plans and provide networks of communications between employees and company's top executives	Select 1 / 2 / 3 / 4 / 5
Failure is expected, even desirable (Every mistake is a chance for learning)	Select 1 / 2 / 3 / 4 / 5
Managers encourage employees to think creatively and enhance the task they are doing	Select 1 / 2 / 3 / 4 / 5
Differences in opinions are welcomed to motivate fresh thinking	Select 1 / 2 / 3 / 4 / 5
Employees are overstressed with deadlines and have no time to innovate and think of new methods to resolve emerging situations	Select 1 / 2 / 3 / 4 / 5
All units are eager to share information.	Select 1 / 2 / 3 / 4 / 5
Information is available and easy to access	Select 1 / 2 / 3 / 4 / 5
Root causes of problems are analyzed to be resolved	Select 1 / 2 / 3 / 4 / 5
Managers command rather than coordinate	Select 1 / 2 / 3 / 4 / 5
Giving employees the freedom to experiment with the process makes it difficult to control the process	Select 1 / 2 / 3 / 4 / 5
High risk is accepted when improvising on critical tasks	Select 1 / 2 / 3 / 4 / 5
Low risk is not accepted when improvising on non-critical tasks	Select 1 / 2 / 3 / 4 / 5

Q14. When I need to improvise, the first thing to do is?

Recall information from past personal experience.	Select 1 / 2 / 3 / 4 / 5
Ask the team to help by sharing experience and learning that was not formally documented in the past.	Select 1 / 2 / 3 / 4 / 5
Ask for help from another organizations that would be willing to share their knowledge	Select 1 / 2 / 3 / 4 / 5
Refer to standard operating procedures.	Select 1 / 2 / 3 / 4 / 5
Pass the problem to managers without trying to solve it.	Select 1 / 2 / 3 / 4 / 5
Break out from conventional methods and think outside the box.	Select 1 / 2 / 3 / 4 / 5
Hire a new member that has experience in solving similar problems.	Select 1 / 2 / 3 / 4 / 5
Benchmark the working procedures of leading organizations	Select 1 / 2 / 3 / 4 / 5
Try to redefine the problem to fit available solutions	Select 1 / 2 / 3 / 4 / 5

Q15. Before implementing the improvisation idea, my team or I practice the following:

Assess Risk of failure	Select 1 / 2 / 3 / 4 / 5

Q16. After improvising, my team or I perform the following:

Document Results and give a degree of satisfaction	Select 1 / 2 / 3 / 4 / 5
Use a computer based network to store information.	Select 1 / 2 / 3 / 4 / 5
Quickly share Feedback about improvisation outcomes to give time for corrective actions.	Select 1 / 2 / 3 / 4 / 5

Q17. If the improvisational decision has high risk of failure and thus can affect my career at the company, I would:

Take the risk and try to perform the required task	Select 1 / 2 / 3 / 4 / 5

Q18. According to my experience, the following qualities help increase my chances of successful improvisation?

Reacting well to time pressure	Select 1 / 2 / 3 / 4 / 5
Having experience	Select 1 / 2 / 3 / 4 / 5
Taking risk	Select 1 / 2 / 3 / 4 / 5
Open to experimenting	Select 1 / 2 / 3 / 4 / 5
Ability to communicate with others	Select 1 / 2 / 3 / 4 / 5

Q19. According to my experience, the following qualities of my organization increase our chances of successful improvisation?

Empowers the employees (involves them in planning and making decisions)	Select 1 / 2 / 3 / 4 / 5
Allows employees to brake some regulations and rules when necessary	Select 1 / 2 / 3 / 4 / 5
Allows experimenting in order to find suitable solution (Biased towards action)	Select 1 / 2 / 3 / 4 / 5
Tolerates non optimal solutions	Select 1 / 2 / 3 / 4 / 5
Defines the roles and responsibilities for each employee	Select 1 / 2 / 3 / 4 / 5
Practices good planning procedures	Select 1 / 2 / 3 / 4 / 5
Stores learning and keeps records	Select 1 / 2 / 3 / 4 / 5
Allows giving authority to the employee with more experience in the relevant field	Select 1 / 2 / 3 / 4 / 5

Q20. Based on my own experience:

All constraints are removed and the task is fully executed from my first attempt to improvise	Select 1 / 2 / 3 / 4 / 5

4. The Arabic survey

١.	المركز في العمل		
٣.	عدد الموظفين في الشركة	٢.	الخبرة في العمل:
☐	١ الى ١٩	☐	أقل من ٥ سنوات
☐	٢٠ الى ٩٩	☐	٥ الى ١٠ سنوات
☐	أكثر من ١٠٠	☐	أكثر من ١٠ سنوات

الارتجالهوخلقأوالتكيفمعطرقجديدةلحلوضعغيرمخططلهأولتحسينالخطةالحالية.

في الأسئلة التالية: ١-بشدةاختلف / ٢-اختلف / ٣-محايدة / ٤-أوافق / ٥-أوافقبشدة

٤. بناء على خبرتي الخاصة، ارتجل عندما يكون هناك:

متطلبات مفقودة (معلومات؛ مواد أولية؛ معدات؛ مرافق مؤقتة؛ مستلزمات السلامة؛ الموارد البشرية ؛الطقس...)	حدد ١/٢/٣/٤/٥
تحديد غير كاف للمهام، تعريف غير كاف لنطاقا لعمل (ضعف في التخطيط)	حدد ١/٢/٣/٤/٥
فرص لتحسين أسلوب العمل أو نتائجه	حدد ١/٢/٣/٤/٥
ظهور ظروف الجديدة أثناء التنفيذ	حدد ١/٢/٣/٤/٥

٥. عادة، ارتجل في حالات:

جديدة ولم تحدث لي أو لأي عضو من أعضاء الفريق	حدد ١/٢/٣/٤/٥
متكررة (حدثت من قبل لأحد أو العديد من أعضاء الفريق)	حدد ١/٢/٣/٤/٥

٦. استنادا إلى خبرتي في البناء؛ الارتجال قد يؤدي إلى الأنواع التالية من الأضرار:

زيادة في استخدام الموارد	حدد ١/٢/٣/٤/٥
زيادة في التكلفة	حدد ١/٢/٣/٤/٥
زيادة في مدة المشروع	حدد ١/٢/٣/٤/٥
انخفاض في أداء السلامة	حدد ١/٢/٣/٤/٥
تعقيد في تطبيق القواعد والضوابط	حدد ١/٢/٣/٤/٥
تأثير سلبي على معنويات العمال	حدد ١/٢/٣/٤/٥
تراجع الجودة	حدد ١/٢/٣/٤/٥
انخفاض في الإنتاجية	حدد ١/٢/٣/٤/٥

٧. استنادا إلى خبرتي في البناء؛ ارتجل باستخدام واحد أو أكثر من الطرق التالية:

أ. الارتجال من خلال إعطاء تعريف جديد للإجراءات المخطط لها.	حدد ١/٢/٣/٤/٥
ب. الارتجال من خلال الجمع بين الموارد بطريقة مختلفة عما كان مخططا له سابقا (على سبيل المثال استخدام الموارد المخصصة لمهام أخرى من أجل تنفيذ لمهمة الحالية).	حدد ١/٢/٣/٤/٥
ج. الارتجال من خلال اقتراح أفكار جديدة ولكن ذات صلة بالإجراءات المعمول بها	حدد ١/٢/٣/٤/٥
د. الارتجال من خلال تنفيذ إجراءات جديدة كليا ولا تشبه أية إجراءات سابقة	حدد ١/٢/٣/٤/٥

٧,١. وبناء على تجربتي الخاصة؛ الأسلوب الأكثر فعالية من ما سبق هو:
(الفعالية :إنتاج أقل قدر من الأضرار أثناء إتمام المهام المطلوبة)

أ	حدد ١/٢/٣/٤/٥
ب	حدد ١/٢/٣/٤/٥
ج	حدد ١/٢/٣/٤/٥
د	حدد ١/٢/٣/٤/٥

٨. عندما ارتجل أواجه الأنواع التالية من الصعوبات:

من الصعب أن تتعرف الى وجود حاجة إلى الارتجال	حدد ١/٢/٣/٤/٥
أساليب الارتجال اللازمة لتسوية الوضع والوصول إلى أهداف غير واضحة	حدد ١/٢/٣/٤/٥
الأهداف غير محددة وغامضة	حدد ١/٢/٣/٤/٥
الظروف المحيطة تتغير بسرعة	حدد ١/٢/٣/٤/٥

٩. قبل اتخاذ القرار الارتجالي ،نقوم فريقي وأنا بما يلي:

يتم اقتراح بدائل مختلفة وتقييمها	حدد ١/٢/٣/٤/٥
يتم اعتماد الحل الأول حتى لو لم يكن الحل الأمثل	حدد ١/٢/٣/٤/٥

١٠. قبل تنفيذ القرار المرتجل، نقوم فريقي وأنا بما يلي:

يتم التوافق بين المدراء في الفريق المسؤول عن تنفيذ المهمة	حدد ١/٢/٣/٤/٥
يتم التوافق بين جميع أعضاء الفريق	حدد ١/٢/٣/٤/٥
لا يتم التأكد من توافق الجميع على القرار	حدد ١/٢/٣/٤/٥
ينبغيان تتوافق جميع الأطراف على القرار المرتجل والا يتم التخلي عنه	حدد ١/٢/٣/٤/٥

١١. وفقا لتجربتي الخاصة؛ عادة يتم اقترح الأفكار الارتجالية من قبل:

المدراء فقط	حدد ١/٢/٣/٤/٥
العمال الملمين بكيفية تنفيذ المهمة	حدد ١/٢/٣/٤/٥
الفرق التي تتعاون لتبادل الخبرات وارتجال بصورة أفضل	حدد ١/٢/٣/٤/٥

١٢. أي نوع من التدريب تعتقد أنه الأفضل لتعزيز القدرات على الارتجال؟

التدريب لمعرفة مجموعة واسعة من الإجراءات بشكل جيد جدا	حدد ١/٢/٣/٤/٥
التدريب لتعلم مفاهيم عالية المستوى بدلا من تعلم الإجراءات	حدد ١/٢/٣/٤/٥
التدريب لتعزيز قدرة العامل على خلق بدائل مختلفة	حدد ١/٢/٣/٤/٥
التدريب لتحسين قدرة العامل على التعامل مع الضغوط(ضغط الوقت مثلا)	حدد ١/٢/٣/٤/٥

١٣. تنطبق العبارات التالية على بيئة عملي:

لا يتم تشجيع الموظفين على تحسين أو إعادة النظر في الطريقة التي يتم بها تنفيذ المهام.	حدد ١/٢/٣/٤/٥
من غير المسموح اعادة النظر بالأنظمة والمعايير	حدد ١/٢/٣/٤/٥
عندما تحدث الأخطاء، يتم اجراء التحقيقات للعثور على من الشخص الذي يتحمل اللوم	حدد ١/٢/٣/٤/٥
التدريب لتحسين قدرة العامل على التعامل مع الضغوط (ضغط الوقت مثلا)	حدد ١/٢/٣/٤/٥
ويتم تشجيع الموظفين لمعرفة المزيد عن وظائفهم الخاصة، ولكن ليس حول العلاقات مع الوظائف والأقسام الأخرى.	حدد ١/٢/٣/٤/٥
يتوجب على المدراء إبلاغ الموظفين عن أداء الشركة وخططها وتوفير شبكات الاتصالات بين الموظفين وكبار المسؤولين التنفيذيين بالشركة	حدد ١/٢/٣/٤/٥
يتم تقبل الخطأ باعتباره فرصة للتعلم	حدد ١/٢/٣/٤/٥
يقوم المدراء بتشجيع الموظفين على التفكير بشكل خلاق ولتحسين العمل الذي يقومون به	حدد ١/٢/٣/٤/٥
يرحب بالاختلافات في وجهات لنظر لتحفيز الأفكار الجديدة	حدد ١/٢/٣/٤/٥
يقع الموظفين تحت ضغط التسليم في المواعيد النهائية وليس لديهم الوقت للابتكار طرق جديدة	حدد ١/٢/٣/٤/٥
جميع الأقسام حريصون على تبادل المعلومات	حدد ١/٢/٣/٤/٥
المعلومات المطلوبة متاحة ومن السهل الوصول إليها	حدد ١/٢/٣/٤/٥
يتم تحليل الأسباب الجذرية للمشاكل ليتم حلها	حدد ١/٢/٣/٤/٥
يقوم المدراء بالقيادة عوضا عن الاكتفاء بالتنسيق	حدد ١/٢/٣/٤/٥
إعطاء الموظفين الفرصة لتجربة اجراءات جديدة يزيد في صعوبة التحكم بالمهمة	حدد ١/٢/٣/٤/٥
يتم قبول احتمال الفشل المرتفع عند الارتجال على المهام الحرجة	حدد ١/٢/٣/٤/٥

١٤. عند ظهور حاجة إلى ارتجال، أول ما يتوجب فعله هو؟

تذكر بعض المعلومات من تجربة شخصية سابقة	حدد ١/٢/٣/٤/٥
طلب المساعدة من الفريق عن طريق تبادل الخبرات والرجوع الى معلومات تم توثيقها في الماضي	حدد ١/٢/٣/٤/٥
طلب المساعدة من شركات أخرى	حدد ١/٢/٣/٤/٥
الرجوع إلى إجراءات التشغيل المعتمدة	حدد ١/٢/٣/٤/٥
تمرير المشكلة للمدراء دون محاولة حلها	حدد ١/٢/٣/٤/٥
الخروج عن الأساليب التقليدية والتفكير في خلق أساليب جديدة	حدد ١/٢/٣/٤/٥
توظيف عضو جديد لديه خبرة في حل مشاكل مماثلة	حدد ١/٢/٣/٤/٥
الرجوع الى إجراءات العمل المعتمدة في الشركات الرائدة	حدد ١/٢/٣/٤/٥
إعادة تعريف المشكلة والأهداف لتتناسب مع الحلول المتاحة	حدد ١/٢/٣/٤/٥

١٥. قبل تنفيذ فكرة المرتجلة، نقوم فريقي وأنا بما يلي:

تقييم احتمالات الفشل	حدد ١/٢/٣/٤/٥

١٦. بعد الارتجال، نقوم فريقي وأنا بما يلي:

ثوثيق النتائج وتقييم فعالية الطرق المعتمدة	حدد ١/٢/٣/٤/٥
استخدام شبكة حاسوبية لتخزين المعلومات	حدد ١/٢/٣/٤/٥
تبادل سريع لنتائج الارتجال لاعطاء الوقت لاتخاذ إجراءات تصحيحية	حدد ١/٢/٣/٤/٥

١٧. إذا كان القرار الارتجالي له مخاطر فشل عالية وبالتالي يمكن أن يؤثر على مسيرتي في الشركة:

أقوم بالمخاطرة ومحاولة تنفيذ المهمة المطلوبة	حدد ١/٢/٣/٤/٥

١٨. وفقا لتجربتي، تساعد الصفات لتالية في زيادة فرصي في الارتجال الناجح؟

قدرة التصرف السليم تحت ضغط الوقت	حدد ١/٢/٣/٤/٥
الخبرة الواسعة	حدد ١/٢/٣/٤/٥
الاستعداد للتجربة والاستكشاف	حدد ١/٢/٣/٤/٥
القدرة على التواصل الجيد مع الآخرين	حدد ١/٢/٣/٤/٥

١٩. وفقا لتجربتي، الصفات التالية للشركة تزيد فرصنا في الارتجال الناجح؟

تحفز الموظفين عبر اشراكهم في التخطيط واتخاذ القرارات	حدد ١/٢/٣/٤/٥
يسمح للموظفين أن يقوموا بخرق بعض الإجراءات والقواعد عند الضرورة	حدد ١/٢/٣/٤/٥
يسمح للموظفين القيام باجراء التجارب من أجل إيجاد حل مناسب	حدد ١/٢/٣/٤/٥
تتقبل الحلول غير المثالية	حدد ١/٢/٣/٤/٥
تحدد الأدوار والمسؤوليات لكل موظف بشكل واضح	حدد ١/٢/٣/٤/٥
تقوم بعملية تخطيط جيد ومدروس	حدد ١/٢/٣/٤/٥
تقوم بتوثيق نتائج التجارب السابقة	حدد ١/٢/٣/٤/٥
يسمح للموظفين ذو الخبرة في المجال المعني بتحمل المسوؤلية واتخاذ القرار	حدد ١/٢/٣/٤/٥

٢٠. وفقا لتجربتي الخاصة:

تتم إزالة كافة القيود ويتم تنفيذ المهمة بالكامل من أو لمحاولة ارتجال	حدد ١/٢/٣/٤/٥