LEAN DESIGN MANAGEMENT – AN EVALUATION OF WASTE ITEMS FOR ARCHITECTURAL DESIGN PROCESS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

SALİH KAAN MAZLUM

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
BUILDING SCIENCE
IN
ARCHITECTURE

JUNE 2015

Approval of the thesis:

LEAN DESIGN MANAGEMENT – AN EVALUATION OF WASTE ITEMS FOR ARCHITECTURAL DESIGN PROCESS

submitted by **SALİH KAAN MAZLUM** in partial fulfillment of the requirements for the degree of **Master of Science in Building Science in Architecture Department, Middle East Technical University** by,

Prof. Dr. Gülbin Dural Ünver ____________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. T. Elvan Altan ____________________
Head of Department, **Architecture**

Inst. Dr. Mehmet Koray Pekeriçli ____________________
Supervisor, **Architecture Dept., METU**

Examining Committee Members:

Prof. Dr. Can Baykan ____________________
Architecture Dept., METU

Inst. Dr. Mehmet Koray Pekeriçli ____________________
Architecture Dept., METU

Assoc. Prof. Dr. Ali Murat Tanyer ____________________
Architecture Dept., METU

Assoc. Prof. Dr. Rifat Sönmez ____________________
Civil Engineering Dept., METU

Assist. Prof. Dr. Timuçin Harputlugil ____________________
Architecture Dept., Çankaya University

Date: 08.06.2015

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name : Salih Kaan MAZLUM

Signature :

ABSTRACT

LEAN DESIGN MANAGEMENT – AN EVALUATION OF WASTE ITEMS FOR ARCHITECTURAL DESIGN PROCESS

Mazlum, Salih Kaan

M. S. in Building Science, Department of Architecture

Supervisor: Inst. Dr. Mehmet Koray Pekeriçli

June 2015, 207 pages

Waste is standing as a major problem in the body of construction industry. Lean thinking in construction accepts any inefficiency as waste which results with more usage of equipment, materials, labor, time or capital in larger quantities than those considered as necessary. Although inefficiency of design stages has been identified as a major factor that reduces the efficiency of construction projects, less attention has been paid on the relationship between lean thinking and architectural design process. Thus, this study focuses on lean wastes of architectural design sector by considering the importance of addressing the problems of the operation in order to eliminate the inefficiencies. In this respect, as the first stage, "8 Waste" categories of "Lean Production Philosophy" and their reflections on architectural design service processes were examined in this study. 28 Waste items under 8 categories were determined in the body of architectural design process as a result of semi-structured interviews conducted with senior architects performing in Ankara, Turkey. In the second stage, a questionnaire was executed over a larger population of architects to examine the "frequency of occurrence", "impact over cost", "impact over duration", and "impact over quality" for each design waste item. The research aims to provide information for the architectural design sector to increase the efficiency of their processes. The statistical analysis of the questionairres shows that there is a shared understanding of impacts of waste items over architectural design processes, with strong statistical evidence over their validity.

Keywords: Lean thinking, 8 wastes, architectural design process, lean design, efficiency

ÖZ

YALIN TASARIM YÖNETİMİ – MİMARİ TASARIM SÜRECİNDE VERİMSİZLİK KALEMLERİ DEĞERLENDİRMESİ

Mazlum, Salih Kaan
Yüksek Lisans, Mimarlık Bölümü, Yapı Bilimleri
Tez Yöneticisi: Öğr. Gör. Mehmet Koray Pekeriçli

Haziran 2015, 207 sayfa

Verimsizlik, yapım endüstrisi bünyesinde büyük bir problem olarak göze çarpmaktadır. Yapım sürecinde yalın düşünce, gereğinden fazla teçhizat, malzeme, işgücü, zaman ve sermaye kullanımı ile sonuçlanan tüm verimsizlikleri israf olarak kabul etmektedir. Yapım aşamasındaki düşük verimin önemli nedenlerinden birinin mimari tasarım aşamasındaki verimsizlikler olduğu kabul edilmişse de, bugüne kadar yürütülen çalışmalarda yalın düşünce ve mimari tasarım süreci ilişkisi üzerine daha az dikkat çekilmiştir. Bir işleyiş içindeki verimsizlikleri gidermenin ilk adımının sorunları ortaya koymak olduğundan hareketle, bu çalışma mimari tasarım sektörünün güncel problemlerini yalın düşünce perspektifiyle ortaya koymaktadır. Bu amaçla, Yalın Üretim Felsefesi'nin 8 İsraf Kategorisi ve bunların mimari tasarım sürecindeki yansımaları üzerine yoğunlaşılmış, Ankara / Türkiye'de çalışan kıdemli mimarlarla yürütülen yarı-yapılandırılmış görüşmeler sonucunda 8 kategori altında 28 farklı verimsizlik kalemi belirlenmiştir. İkinci aşamada ise mimarlardan oluşan daha geniş bir araştırma evreni üzerinde uygulanan bir anketle söz konusu verimsizlik kalemlerinin karşılaşılma sıklığı ile proje maliyeti, proje süresi ve proje niteliği üzerine etkileri araştırılmıştır. Bu araştırma ile mimari tasarım sürecinde verimin artırılmasına yönelik katkıda bulunmak hedeflenmiştir. Anket sonuçları üzerinden yürütülen analizler israf kalemlerinin mimari tasarım süreci üzerinde etkileri ile ilgili bir uzlaşma olduğunu ortaya koymuştur.

Anahtar kelimeler: Yalın düşünce, 8 israf, mimari tasarım süreci, yalın tasarım, verim

ACKNOWLEDGEMENTS

I would like to thank to my advisor Inst. Dr. Mehmet Koray Pekeriçli for his involvement, guidance and criticism throughout this research. I am also thankful to Assoc. Prof. Dr. Ali Murat Tanyer for his support and assistance during my whole time in graduate program.

I also wish to express my sincere thanks to my superiors and workmates in Ministry of Environment and Urbanization, General Affairs of Construction Works. It would be much more difficult to complete this study without the fellowship and support of Project Department. I would also like to thank my classmates from department of architecture for their attention and effort in the process.

I am also grateful to all the architects for getting involved in the interviews despite their busy schedule, listening to my presentation, answering the questions patiently and sharing their precious remarks and suggestions. Besides, I would like to thank Chamber of Architects Ankara Branch for distributing my survey and its members for answering the questionnaire with patience.

I wish to express my gratitude to professors from Department of Civil Engineering for their patience and positive attitude towards an architect in their classes through the whole program.

Finally, I would love to express my innermost thankfulness to my beloved family members; Buket, Erdal and Zeynep. Including this work, no success I achieved in my life would be possible without their endless support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BIM	Building Information Modeling
BPR	Business Process Re-engineering
C&D	Construction and Design
CE	Concurrent Engineering
CWM	Construction Waste Management
ISO	International Organization for Standardization
JIT	Just In Time
LC	Lean Construction
LCI	Lean Construction Institute
LPDS	Lean Project Delivery System
LPS	Last Planner System
SPSS	Statistical Package for the Social Sciences
TPS	Toyota Production System
TQM	Total Quality Management
VBM	Value Based Management
VSM	Value Stream Mapping
WM	Waste Management

CHAPTER 1

INTRODUCTION

In this chapter, firstly, background information regarding the argument of thesis is presented. Then it is continued with aim and objectives of study and its possible contribution is argued accordingly. The chapter is concluded with disposition, an overview of the report content.

In our day, waste concept and its possible preventions in construction industry are widely argued. When design and production relationships are considered, construction industry is distinctive in comparison with other industries. Every project has characteristic features. To illustrate; even if the same architectural design is being constructed on different places, there may be a necessity of alternative design and planning decisions due to land and climate conditions.

Therefore, the adaptation of lean production philosophy for construction industry requires a special effort when compared to other production industries. The number of decisions to be made in design, planning and construction phases for generating a product is significantly higher than other manufacturing sectors.

Accordingly, it is considered that application of lean production philosophy in construction industry that embodies architectural design phase could be helpful for increasing the efficiency of the whole process. In this context, this study focuses on the lean waste items in architectural design processes.

1.1 Background Information

In addition to the contribution of construction industry to the general progress of the society, it has also been perceived as a major contributor to the total waste generation (Lu & Yuan 2011). Waste has got its place in the construction industry as a major problem. By considering the high volume of trade between construction and other industries, wastes in sector can be seen as a reason for both the inefficiencies of the construction industry and other related industries. That's why it is vital for the community to reduce the waste in the construction industry (Polat & Ballard 2004).

The waste in construction shows its effects over the environment indispensably. So it also should be seen as a remarkable point for the environmental concerns. To illustrate, Environmental Protection Department of Hong Kong defined construction waste as "anything generated as a result of construction activity and then abandoned, regardless of whether it has been processed or stockpiled" (Zhang et al. 2012).

Lean construction (LC), lean project management and value engineering are different project management approaches that were developed and adapted to make progress on the performance of the construction industry (Al-Aomar 2012). So it is possible to deduct from the literature that the potential reduction of waste in the construction industry will be beneficial for both economical and environmental reasons in a Global scale.

Lean principles may play an important role for constructing the base for the waste minimization activities in construction and many other industries. Lean Construction is the implementation of a new thought system through the management process of construction production. Providing continuous and efficient information flow is its pivotal practice for the advancement of supervision system. The aim of whole system is to reduce the loss of the process (Issa 2013). According to Marhani et al. (2012), LC is a system for achieving the needs of clients in the industry by intending to increase productivity and health and safety by reducing waste. It is a way to minimize material, time and effort waste in order to reach to the possession of maximum value.

Previous studies emphasize the effect of early design phases to reach the aim of minimizing the uncertainty and maximizing quality in construction projects. That's why the importance of design stage has been remunerated. Nevertheless, construction phases had been and are still being exposed to more attention in the body of lean construction researches and practices. This situation – trying to solve problems which have already existed during construction - leads to challenges part of which can be eliminated through an effective design process. Namely, focusing only construction phase to apply lean thinking complicates to address the waste and increase the value in the whole process (El. Reifi & Emmitt 2013). Despite all, lean construction researches focused less on earlier design stages in comparison with on-site construction stages. According to Osmani et al. (2008), the influence of architects over Waste Management (WM) can grow with the understanding of the issues, complications, and opportunities related to waste prevention.

The concept of “lean design” has not been argued as much as lean construction by literature. (Freire & Alarcón 2002; Whelton 2004; Emmitt et al. 2004). Although there is not a universally accepted definition, Jørgensen and Emmitt (2009) noted that lean design in construction is used for approaches, principles, and methodology internalized for managing design and/or progress operation. Lean philosophy presents a unified understanding of designing and making in principle. Moreover, some leading researchers in lean construction recommended that the production concept should be standing for both designing and making (Koskela 2000; Ballard & Zabelle 2000; Ballard 2002).

These principles of lean design are expected to contribute for the overall efficiency and value of both the design and construction processes. Because design process is not a linear production process and every single construction product requires a unique architectural design, the principles to be employed for achieving maximized value can differ under different circumstances.

At the same time, it is considered that an increment in efficiency of architectural design stage may contribute for decreasing duration and cost required while increasing the quality of overall project. By this manner a higher level of client value may be possible to achieve from lean looking angle.

1.2 Aim and Objectives

Aim of this study is to determine lean design waste items and evaluate their impacts over project value parameters. To reach this goal, the author tried to;

- Compile current wastes in design process,
- Group lean design waste items under 8 waste categories,
- Investigate frequency of occurrence, impact over cost, impact over duration and impact over quality parameters for each waste item,
- Find waste items that are highly influential on the reduction of project value,
- Seek if there is any significant difference of answers of architects from different professional backgrounds,
- Evaluate the impact of waste categories for different value parameters, and
- Highlight the most effective waste items and their sources to be eliminated for increasing the efficiency of both design and construction phases.

1.3 Contribution

There are many research studies presented in the literature on waste management, lean thinking, lean construction and design management; however, there is no study focused specifically on determining waste items of architectural design management encountered. The contribution of this study is to present a list of architectural design waste items and evaluate their impact over different project value parameters. By this manner, it is aimed to guide design industry for determining steps to be taken for increasing efficiency level of both design and production stages of construction projects.

1.4 Disposition

This dissertation contains five chapters. In the first one, background information, aim and objectives, contribution and disposition are provided.

The second chapter consists up of a review of literature that mentions previous studies related with waste management and construction, lean thinking and production, lean construction, design management, and lean design principles. The chapter is concluded with a critical analytical discussion of the literature in question.

Next chapter is named as material and method. It firstly presents sample selection, structure and general remarks of the interview conducted. Then the results of interviews are evaluated and waste items are classified under 8 waste categories. Finally, execution, participants and structure of the questionnaire are given in the last section of the chapter.

Results and Discussion is the name of fourth chapter in this thesis. Initially, professional information of sample population is given according to answers in the first section of questionnaire. Then the results of the second section questions are presented. Statistical tests are employed for further analysis in this section.

Finally, Conclusions is placed as the last section of the dissertation. In this chapter, a brief summary of research is provided, then main results and discussion is given place, and the study is concluded with its limitations and recommendations for further researches.

CHAPTER 2

LITERATURE REVIEW

This chapter is comprised of the issues searched from the literature, which are presented under three main sections. The first section covers the waste management and its relation with the construction industry. In the second section the lean concept, lean thinking and its principles are explained. The third section contains an overview about the role of design process management in construction and its relation with lean thinking. The chapter is concluded with inferences drawn from the literature review.

2.1 Construction and Waste Management

By referring to lean concept, the literature does not propose two different definitions for lean construction and lean design. By considering its main principle, which is increasing customer value by reducing waste, it is concluded that the lean philosophy and its essential components mentions design and production processes together (Jørgensen & Emmitt 2009). From this point of view, lean design is considered as an inseparable part of lean construction. It is considered that in order to discuss lean design; lean construction, and design and construction relationships should be mentioned first.

In this section, firstly, it is aimed to represent various definitions of waste in construction and remarks in the literature why it is important. Following, classification, and sources of waste management in construction industry is discussed in the light of previous works. Then the relationship between design process and waste relationship is investigated. Finally, strategies developed by researchers to cope with waste are analyzed in construction industry.

2.1.1 Waste in Construction

The term construction waste is used to refer the waste which arises from construction, renovation and demolition activities (Kofoworola & Gheewala 2009). The excessive amount of material and damaged products existed during the construction activities can also be counted as waste in construction (Roche & Hegarty 2006).

Koskela (1992) made the definition of waste as "any inefficiency that results in the use of equipment, materials, labor or capital in larger quantities than those considered as necessary in the production of a building". In the study conducted by Serpell and Alarcón (1998), the effort spent to reduce waste is correlated with the elimination of non-value-adding activities to improve the performance of construction. It is more simply described as "activities, resources, rules *etc*. which can be eliminated without reducing customer value" (Osmani 2012).

Different stakeholders on the subject of construction waste generation, such as governments, practitioners, and academics have been spending efforts for performing progress which is required for efficient and cost effective environmental management to reach a reduced level of Global construction waste (Esin & Coşgun 2007). The industry is encouraged to pay more attention over the WM due to the decreasing availability of landfill areas and the cost of land filling (Baldwin et al. 2008).

2.1.2 Significance of Waste Management in Construction

Waste is a major problem in construction industry. It both has impacts on the efficiency of the industry and the general economical circumstances of the Globe. This is simply due to the major and direct effect of construction industry on many others by both providing products to them and receiving of merchandise from other industries. Therefore, reducing waste in construction industry is vital for the community (Polat & Ballard 2004).

Although it is difficult to measure the amount of waste in the industry, a wide range of studies from different regions of the world emphasize the high amount of inefficiencies can be encountered that negatively affect the production costs of construction (Formoso et al. 2002).

There are various management approaches generated by considering remarkable effects of construction industry over the environment, *i.e.*, ISO 14000, This quality standard is one of the products of a whole management system structured to enhance environmental performance along every kind of industries including construction. Collaterally, it is supported in construction services to manage waste for protecting the environment (Zhang et al. 2012).

Amount of waste existing in construction industry is on a very high level. The reduction or elimination of waste in construction could bring grand benefit to society due to the major and direct effect of construction on many other industries considering purchasing the inputs from them and providing the products to nearly all of the other industries (Arditi et al. 1985).

It is vital for construction companies to get adapted to today's competitive market conditions. This can be handled by increasing the effectiveness of their work by improving the quality, reducing the cost and increasing the profit. This is the reason why combining high quality, low cost and higher project speed has become the focusing point of engineers and managers in the industry. So there is a consensus among the construction managers that the industry is vulnerable to suffer from wastes, overruns, delays, errors and inefficiency (FMI & CMAA 2005).

2.1.3 Sources of Waste in Construction

Yuan (2013) attributes the poor management of construction waste with absence of regulations which can lead the contractors, unawareness of stakeholders in the industry, not having waste management plans at the project level, poor management of waste generated on site and the lack of long-range action plans developed by governmental organs especially about waste disposal and land filling activities.

Yuan's work further highlights two major barriers against effective waste management: (1) the unawareness of the designers about the construction waste management at project design stage, leading to remarkable alterations in following construction activities, (2) usage of ineffective plans to manage waste in construction phase (2013). So it can be interpreted that design phase has been seen as one of two main reasons for waste in construction.

A more comprehensive study is conducted by Osmani *et al.* (2008). According to authors, there are ten main origins of waste in the body of construction works:

- *Contractual*: errors and incompleteness of contractual documents.
- *Design*: design alterations, complicated details and design, finishing errors, uncertain and incompatible list of conditions, communication and coordination problems.
- *Procurement*: order failures, excessive funds due to adversity of ordering small quantities and provider mistakes.
- *Transportation*: accident losses, vehicles' hardness of reaching construction site, inadequate preservation and habits during loading and unloading equipment and material.
- *On-site management and planning*: lacking and insufficient waste management planning, late information for orders and materials, missing on-site material monitoring and supervision.
- *Material storage*: unsuitable allocated place for storage, incorrect storage procedures, distant placed materials from application area.
- *Material handling*: unconstrained materials supplied, insufficient on-site conveyance, wrong utilization of materials.
- *Site operation*: inattention based mistakes, unemployed materials and products, equipment breakdowns, unqualified workmanship, unsuitable material usage, time restrictions, code of conduct violation.
- *Residual*: poor planned implementation (overproduction), defective cutting procedures, inefficient dimension selection of materials, unsuitable packing.

Other problems such as weather, barbarism and burglary were also addressed by authors as waste sources in construction works without putting in any of origins above.

2.1.4 Design and Waste

In literature, there is a consensus on the relationship between design and construction waste. Poor design causes growth in waste generation in construction projects (Osmani et al. 2008). Gamage *et al.*'s study indicates that the lack of input from trade parties at design stage and the emphasis on client in the design process leads to an increase in the amount of waste (2009). The study conducted by Ordoñez and Rahe emphasizes that there is a strong relation between design and waste (2013). It is revealed that a proximate of 33% of construction waste generated on-site is related to design directly or indirectly. On the contrary, there are no enough attempts to minimize the construction waste related with design activities.

An inspirational viewpoint is presented by Baldwin *et al.* regarding the contribution of designers' choices over the construction waste generation. According to authors, if designers will take reliable decisions, it has a vital necessity for them to have an understanding and evaluation of "waste in general" and "physical waste". They should be able to predict the potential savings and negative consequences that will occur according to their decisions and the implications of them over both the design and construction process. The details of production process are important to be known by the designer to eliminate waste as much as possible before the production starts. At this point life cycle cost and impact are two important concepts deserving special consideration (Baldwin et al. 2008).

Lu and Yuan (2011) addressed project design as an essential issue with maintenance and demolition strategies to be investigated in the future for better Construction and Design Waste Management.

2.1.5 Construction Waste Management Strategies

Three "Rs" principle dominated researches about strategies of Construction and Design (C&D) WM. 3Rs here refer to *Reduce, Reuse* and *Recycle* which are in order with respect to the desired level in WM strategy (Lu & Yuan 2011). Being parallel with lean thinking, there is a consensus in the literature that the most effective strategy for waste management is to prevent its generation. Providing that, there will be no effort spent for reuse, recycle and disposal activities besides its economical advantages (Esin & Cosgun 2007). Due to its minimal effects on environment, Yuan claims that reduction of waste is by far the best management action in comparison with others in 3R strategies (reduction, reuse and recycling) of construction waste management also by considering limited landfill to receive construction waste and low maturity level of market for recycle of waste (2013). The importance of waste reduction has also been realized by the researchers in the field such that, C&D waste reduction is the most studied topic with waste generation among all the strategies like recycling, waste disposal, and reuse (Lu & Yuan 2011).

The "zero waste" vision of the construction industry can get closer to achieve by the involvement and commitment of all stakeholders to reduce waste at source and develop efficient waste management strategies such as reuse and recycle of materials and components (Osmani 2012). If it is aimed to develop the efficiency of C&D WM, it is recommended to get more focused on the design maintenance and demolition stages in the future (Lu & Yuan 2011).

Yuan (2013) listed seven strategies for effective construction waste management (CWM) in a local region: (1) every stakeholders involved in the industry should be responsible in an established order, (2) legislative steps should taken in detail about CWM, (3) studies should be conducted to obtain the numbers about the WM amount to raise awareness, (4) a systematic CWM plan should be implemented for the whole life cycle of the construction projects, (5) a pilot program of applying recycled materials should be implemented, (6) a waste research institute should be established (7) training and promotion activities should be organized to raise the awareness of CWM.

The solutions developed in the literature for waste reduction is summarized in five categories by Lu et al. (2011): (1) reducing waste through government legislation, (2) reducing waste by design, (3) developing an effective waste management system, (4) use of low waste technologies, and (5) improving practitioners' attitudes toward waste reduction.

Lu et al. (2011) emphasize the role of multidisciplinary efforts for effective C&D WM. Coordinated inputs from different disciplines such as administration, finance, legal, planning, and engineering are substantial. These should also feed with environment, social, and economical concerns together because the topic is getting to be an issue of sustainable development.

2.1.6 Waste Management Habits of the Industry

It is difficult to implement waste management strategies in construction in comparison with other industries due to the unique requirements and conditions of each project. The uncertainties about the medium of production, splintered structure of the temporary organizations for the procurement of buildings and extreme level of time and cost pressure playing important role over the project characterization (Teo & Loosemore 2001).

Osmani notes that despite the existence of various tools for handling and better managemenet of waste generation on-site, – such as SMARTWaste (UK) and WasteSpec (USA) – these tools focus on the waste already generated. There is not enough effort for preventing the waste from being generated by eliminating waste at source as in design phase (2012).

2.2 Lean Thinking and Production

There are considerable performance improvements achieved in various manufacturing industries with the increase in productivity in the last twenty years (Polat & Ballard 2004).

According to Lee *et al*. (1999) “Lean Production” is a new philosophy for production which removes various types of waste in order to provide a continuous improvement. Womack (1999) claims that the main idea behind lean production is eliminating all kinds of waste to fulfill the needs of customers in a more preferable way.

The measurement of waste is a reliable method for evaluating the effectiveness of a production system because it shows the areas of the production that needs to be developed and enlightens main reasons of inefficiency. In comparison with traditional parameters to be measured, waste measures offer more effective way to manage the process due to its ability to model the operational costs properly and generate meaningful information for the personnel. It creates proper conditions for the practice of decentralized control of the work. (Formoso et al. 2002).

2.2.1 Toyota Production System

The concept of Lean Production is based on elimination of waste as the main focus for the improvement of process. It is actually a milestone in manufacturing. Its origins are based on TQM (Total Quality Management) and Just in Time (JIT) philosophies in the 1950s, in Japan (Formoso et al. 2002). Even if the guidelines and notions of Lean Production has been promulgated in recent years in various industries (Koskela 2000), the most featured and widely known implementation of the system so far is Toyota Production System (TPS).

Aziz and Hafez (2013), notes that Toyota Motor Company is the place where the production system called as “lean production” or “Toyota Production System” is generated and performed successfully since 1950s. Being influenced from Total Quality Management (TQM), lean thinking developed a simple set of objectives for the production system design. This system aims to reduce machine setup time and includes;

1. Identification and delivery of value to customer value and eliminate anything that does not add value,
2. Organization of production as a continuous flow,

3. Perfection of the product and creation of reliable flow while providing the distribution of the information and decision making,
4. Without an inventory, seeking perfection with respect to the customer requirements while delivering.

Similarly, five principles were identified by Womack and Jones (1996) to present the basics of lean thinking:

1. Accurate specification of value together by client and producer for each product. Value stands for what client accepts to pay in return.
2. Identification of value stream for specific product. Demonstration of value adding, non value adding and unnecessary activities. Exclude non value adding unnecessary activities in short term, minimize non value adding activities in long term.
3. Push for value generation flow without any cutoff in process.
4. Do not perform a work until required by next step of production. Let the client pull value from producer.
5. Seek perfection (provide continuous improvement).

2.2.2 "8 Wastes" in Production

The operational perfection has been shown as the major source of Toyota's attention grabbing strong and stabilized performance. In other words, "operational perfection" can be seen as the most significant concept in the structure of the production system.

The first step of starting the production has been seen as to look at the process from the customers' angle of view and determine what they expect in the end of the process. By this way, it is aimed to determine value adding and non-value adding activities. This type of working helped Ohno (1988) to identify and categorize the 7 wastes, Liker (2004) added 8^{th} type of waste as follows;

1. **Overproduction**: Producing more than required leading to overstaffing, storage and transportation costs. Causes significant amount of resource to be tied up

which otherwise could be used for value adding operations. The causes of overproduction can be listed as;

a. Prediction based production
b. Wrong automation applications
c. Long lasting installations
d. Unpredictable customer needs
e. Alterations in technical implementations

2. **Waiting**: All the time which is not spent for value-adding activities. Some key reasons for overproduction are;
    a. Unbalanced workforce/load
    b. Unpredicted downtime
    c. Extravagant set-up times
    d. Worthless supplier support
    e. Worthless process quality
    f. Prediction based production

3. **Transportation**: Carrying works which does not add value to final product for customer. Causes of transportation waste are;
    a. Unplanned plant layout
    b. Misconfigured flow
    c. Large batch sizes
    d. Prediction based production

4. **Overprocessing**: Unnecessary transactions involved in the process that can be leaded by;
    a. Poor process evaluation
    b. Documentation problems
    c. Problems in customer value determination
    d. Internalizing just in-case philosophy
    e. Inessential checking processes
    f. Prediction based production

5. **Motion**: Any unnecessary movement performed by sources. Its causes can be lined as;
    a. Layout problems
    b. Unpredicted downtime
    c. Poor designed workplace
    d. Ineligible check mechanism

6. **Inventory excess**: Excessive amount of supply stored with respect to customer needs and value. Key reasons addressed below;
    a. Gaps in production flow
    b. Unsteady suppliers
    c. Unbalanced workforce/load
    d. Prediction based production
    e. Internalizing push production system
    f. Misunderstood customer value/needs

7. **Defects**: Deviation of products from customer requires or specification. Although it is the easiest waste to observe and understand, its effects are more than perceived in the first time. Causes of defects are;
    a. Quality control problems
    b. Design alterations
    c. Process documentation problems
    d. Misunderstood customer value/needs
    e. Poor automation capability

8. **Unused Employee Creativity**: This is a situation of not using the potential efficiently, which makes an organization to benefit less than possible. Reasons possible to list;
    a. Teamwork problems
    b. Lack of training
    c. Poor relationships/communications
    d. Misconfigured flow

Table 2.1 Types of waste in production

Types of Waste in Production	
1	Overproduction
2	Waiting
3	Transportation
4	Processing
5	Inventory
6	Motion
7	Defects / Correction
8	Unused Employee Creativity

2.2.3 Lean Principles of Toyota Production System

Continuous success of Toyota over implementing lean tools and methods is based on a philosophy rooting in understanding of people and human motivation. In order to objectify the requirements of the philosophy, 14 main principles pointed by Liker (2003) are addressed at this point under four high level categories: philosophy, process, people and partners, and problem solving.

1. Philosophy (long term thinking)

Principle 1: Base your management decisions on a long-term philosophy, even at the expense of short term financial goals.

This principle can be seen as the origin of "Toyota Way" thinking. By focusing on long term benefits it is aimed to create the best value for customers. Even sometimes short term benefits are not hesitated to sacrifice for customer benefit. This principle is possible to catch in the structure of all the other principles.

2. Process (Eliminate Waste)

It is detected that the 90% of the processes are waste while only 10% of them are creating value for the end product in most of businesses. That's why the primary object of lean thinking is eliminating waste.

Principle 2: Create continuous process flow to bring problems to the surface.

One-piece continuous flow is the core implementation of this principle to reduce the waste from the quickest way. It requires steps like batch processing methods to minimize the effect of long changeover times. Lean cell concept is introduced and encouraged instead. Cell processing a one piece flow are strongly linked in the production process. This process also contains determining the flow rate of material. At this point, it is noted that problem solving and preservance culture should be internalized to apply such a hard type of production implementation. Its benefits are listed as building in quality, creating real flexibility, creating higher productivity, freeing up space, improving safety, improving morale and reducing cost of inventory.

Principle 3: Use "pull" system to avoid overproduction.

Pull system mainly means producing only required material for the next operation in the line. This is required for reducing the overproduction. Pushing the production line according to the schedule determined by the producer has been seen as a problem. Pulling the inventory according to customer demand is suggested. By this way, it is aimed to give the customer what, when and in exactly in the amount of s/he wants.

Principle 4: Level out the workload *(heijunka).*

Eliminating overburden to people and equipment and eliminating unevenness in the production schedule are also substantial. This type of working is assimilated to a slow and consistent tortoise and because it creates less waste, preferred to a speedy hare which goes as fast as possible and then stops suddenly at times.

Principle 5: Build a culture of stopping to fix the problems, to get quality right in the first time.

Although most of its opponents internalize the idea that “production line never stops”, Toyota encouraged its employees to stop the line to identify the faults. This also can be seen as a reflection of first principle. The velocity of production is sacrificed in order to get the product right in the first time. The fact that every unsolved problem causes a bigger one upstream is recognized by the company.

Principle 6: Standardized tasks are the foundation for continuous improvement and employee empowerment.

It is believed that a process can be improved until it has been totally standardized. And standardization is also required for development, in this respect, workers are encouraged to develop their own standardized work procedures. This kind of an operation attitude can be described as bureaucratic, on the other hand, this bureaucracy brings standardization of tested and proven methods created for waste reduction.

Principle 7: Use visual control so no problems are hidden.

Visual signs are substantially minded in “Toyota Way”. Because it is used as a tool for making all those concerned gain awareness about the process. It is useful to be able to have an easily-understandable look at the process including information about the equipment, inventory and workers. 5S Program is followed at this point by everyone involved. Sort-Strengthen-Shine-Standardize-Sustain represent five steps for regulating the efficient space, productivity, work share, work environment and searching time reduction.

Principle 8: Use only reliable, thoroughly tested technology that serves your people and processes.

Toyota has an understanding which does not hesitate to participate in new technical fields, while doing this, it is considered to involve the technology which directly add value or reduce waste in the process. There is a strong selectivity performed in the frame of “pull system” at this point. The structure and needs of manufacturing pull technology application. It does not allow Information Technologies (IT) to push itself. Because automated systems are more difficult to change and tune than manual systems, it is vital to prioritize process itself than automation.

3. People and Partners (Respect, challenge and grow them)

Principle 9: Grow leaders who thoroughly understand the work, live the philosophy and teach it to others.

Those fourteen principles of the system need time for total absorption. This makes people involved obliged to be educated and trained. Because, lean is not something can be applied and then forgot, it is a philosophy to be internalized. Moreover, this internalization should be performed in every single unit of the whole organization. This structure will help to achieve lean goals to grow the leaders from its own constitution by encouraging responsibility without authority.

Principle 10: Develop exceptional people and teams who follow your company's philosophy.

Teams are established around Ken Blanchard's The One-Minute Manager Builds High Performing Teams (2004) and the five steps of team building (known as forming, storming, norming, performing and adjourning). Team building is a serious job, not a one-minute task, should be seen as a significant investment can take months. Teams should be kept small (4-5 people) and numerous management tiers (maintaining the 4:1 or 5:1 ratio), admittedly sounding contrary to the low overhead concept. Motivation is another important concept which is based on team performance rather than individuals.

Principle 11: Respect your extended network of partners and suppliers by challenging them and helping them improve.

Attitude towards suppliers is much like attitude towards employees which is to encourage, force and help them for better with respect and esteem. Toyota does not use lowest-price, competitive bid. Moreover, they don't charge for mistakes or leave alone to solve a problem. The company works with the supplier to achieve price targets, cross-functional teams are established for fixing problems.

4. Problem Solving (continuous improvement and learning)

Principle 12: Go and see for yourself to thoroughly understand the situation *(genchi genbutsu).*

This principal is vital for designers and managers to see the effect of the design and planning over the production process. Generally it is designers and managers decide for the methods to apply. So that they can be able to develop new methods for reducing the waste if they observe any. All employees from top to down expected to do this. It is said that "without experiencing the situation for yourself – genchi ganbutsu, you really do not have an understanding of how it can be improved".

Principle 13: Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.

Instead of disconcentrated quick work style, a smooth, steady, methodical approach is given preference. This idea is valid for decision making phases. After the decision is given, quick implementation is targeted. The action plan is includes; (1) find what's going on, (2) determine underlying causes, (3) consider a broad range of alternatives, (4) build consensus on the resolution, and (5) use efficient communication tools.

Principle 14: Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).

This principle can be seen as a mix of some preceding principles to be applied to the whole organization. In order to determine the root cause of the problems a technique is developed including; initial problem perception, clarification of the problem, locating area/point of cause, investigation of root cause (5 whys), counter measurement, evaluation and standardization. Because there is a different metrics understanding, organizations focusing on direct results rather than process itself may not be able to success. TPS says process should be monitored and desired results will be an outcome in the natural flow.

2.2.4 Lean Thinking and Construction

Although many of the TPS principles and tools are feasible in construction, there are different ones from those of TPS in lean construction (Sacks et al. 2009). However, the researchers interested in the adaptation of these practices in construction industry developed strategies for efficient construction process.

A huge ratio of research activities about C&D WM focused on the material loss in construction rather than "non-value adding work". There is a need in the field for more studies investigating non-value adding works in construction (Lu & Yuan 2011).

In addition to the contribution of construction industry to the general progress of the public conditions, it has also been perceived as a major contributor to the total waste generation (Lu & Yuan, 2011).

It is a proven fact that value maximization and advanced sustainability are results and advantages of LC implementations in the construction industry (Marhani et al. 2012).

The results of the survey conducted by Polat and Ballard (2004), indicated that Turkish construction industry greatly suffers from waste due to the lack of lean thinking philosophy.

Managing construction with the guidance of lean principles is distinctive among other industries in practice due to its;

1. Clear objective sets for the delivery process,
2. Aim of maximizing the value for customer in the project level,
3. Concurrently designed process and product,
4. Application of production control throughout the life of the project.

So the first aim of the lean construction is addressed by Aziz and Hafez (2013) as to entirely understand the nature of the production activities (*i.e.,*: their requirements and bottleneck, *etc*.), the effects of dependence and the variation along supply and assembly chains. As like in lean manufacturing, “planning” and “control” are two main factors that should keep working together through a project in lean construction. At this point, planning can be explained as the activity of criteria defining for success and strategy development to achieve while control is described as causing events to conform to plan and triggering learning and re-planning.

2.2.5 Lean Construction; Definitions

Lean Construction is the implementation of a new thought system through the management process of construction production. Providing continuous and efficient flows is its pivotal practice for the advancement of supervision system. The aim of whole system is to reduce the losses in the process (Issa 2013). According to Marhani et al. (2012), LC is a system for achieving the needs of clients in the industry by intending to increase productivity and health and safety by reducing waste. It is a way to minimize material, time and effort waste in order to reach to the possession of maximum value.

Correspondingly, Lean Construction Institute (2004) described LC as a new attitude for project delivery that focuses on production management. It is also claimed that application of lean in construction changes the method of work is performed throughout the whole process. The main objectives of lean production are adopted in lean construction: maximize value and minimize waste.

According to Howell (1999) lean construction becomes distinct when compared to traditional practice by having certain set of objectives, aiming to maximize value for the client from the project stage, planning and designing product and process simultaneously and monitoring and controlling production during the whole life of the project.

2.2.6 Lean Construction History

In the literature, LC history is directly associated with the Toyota manufacturing system which generated lean thinking and production principles. Bertelsen (2004), regards LC as an orientation and execution study of Japanese Manufacturing principles in the body of construction industry. In their study, Cullen et al. base the roots of LC to the principles of Toyota Motor Company implemented in the late 1950s and 1960s under the leadership of Taiichi Ohno (2005). In order to achieve a "perfection standard", LC internalized Ohno's production system design.

However, it was not easy for the construction to gather management strategies from other manufacturing industries due to its unique and complex products produced in uncertain environmental conditions under great time and schedule pressure. Howell (1999) underlined the possible amount of increase in the value of the construction industry by focusing on the management of the whole process. This can be achieved by establishing logical relationships with full understanding of physics between the activities instead of managing the process activity by activity with the aim of reduce the cost and duration of each step separately.

2.2.7 Lean Construction Concepts

With the use of precise materials and production of less waste, it is possible to reduce costs and create more beneficiary environment for construction companies. Furthermore, construction period will be shortened with a proper strategic planning approach. At this point, there are key concepts to be implemented in LC practices by the stakeholders in the industry (Marhani et al. 2012). Alinaitwe (2009) depicted the concepts including Just-In-Time (JIT), Total Quality Management (TQM), Business Process Re-engineering (BPR), Concurrent Engineering (CE), and Last Planner System (LPS), Teamwork, Value Based Management (VBM) (Harris & McCaffer 1997); and OHSAS 18001. There is a consensus on the interconnection of these concepts in the literature in order to minimize construction waste and improve construction performance (Marhani et al. 2012).

Just In Time (JIT): A production approach focuses on waste elimination in a planned way and continuous improvement in efficiency of process. The objective is to have zero inventories. By this means it is aimed to produce only necessary product in required time interval (American Production and Inventory Control Society Dictionary, 1992). Koskela (1992) related the term with waste concept directly and emphasized the necessity of constant progress of processes, equipment and methods for waste elimination. Salem et al. (2006) claimed that three mechanisms linked with JIT: optimization of inventory in line with customer requests backwards, leveling construction and reduce in amount of preparation activities.

Total Quality Management (TQM): Briefly, TQM is an approach that focuses on the process and seeks for performance improvement by covering all components involved at every stage of the work (Imai 1986). The importance of continuity of effort is emphasized by George and Jones (2008) for achieving perfection in quality of product or service provided. Summers (2005) remarked the need for accurate understanding of customer value for an effective total quality management application.

Business Process Reengineering (BPR): Development through fast and significant increase in institutional performance by beginning with conceptual design or redesigning base of business improvement (Small & Yasin 2011). Any activity that aims for rapid delivery of products and services to client or seeks for high quality and low cost are seen as business process George and Jones (2008).

Concurrent Engineering (CE): Especially focuses on product design phase. Incorporates the limitations of further stages into the conceptual stage and tightens of variation monitoring towards the end of planning and designing phase (Koskela, 1992).

Last Planner System (LPS): It is a clear and applicable contribution to lean construction aiming to reach a workflow and production monitoring and controlling in a pull manner (Ballard 2000). Seeks for arranging common attempt and expanding the reliability of colleagues' commitments (Seppanen et al. 2010). There are detailed considerations for assignments of production units; named as lookahead plans. In general, the units are determined from 3 to 12 weeks ahead to identify possible limitations and requirements. There are activities classified as "should be done", "can be done", "will be done" and "did". Last Planner System converts "should be done" activities into "can be done" by taking limitations of conditions into consideration. Next, weekly or daily based "will be done" activity plan is created from "can be done" activities. Percent Plan Complete (PPC) is another important concept of system that is used for monitoring process and it is calculated by the ratio of "did" activities to "will be done" activities. (Ballard 2000).

Teamwork: Teamwork has been seen as an indispensable component of lean by considering its possible contribution to increase the efficiency. It is beneficial for integrating different skills of individuals who are gathered for mutual objectives. Maximum efficiency and creativity can be obtained by well coordination of different characters in a mutually supportive management (Excellence 2004).

Value Based Management (VBM): In this approach, project value and product value are considered as two main value types. Value for customer stands for product value while value for the employees and stakeholders is identified as process value (Bertelsen 2004).

OHSAS 18001: Occupation Health and Safety Assessment Series, generated for assisting construction industry for increasing its performance in decreasing health and safety risks (OHSAS 18001, 2012).

2.2.8 Lean Construction Studies

It is noted in the literature that, the actual level of lean construction is at a stage of focusing on the definition of lean construction theory. So there is a lag between the theoretical and practical developments in the industry. Although LC theory offers frameworks to be applied, it can be tough to convert and implement LC theory in the practice of construction industry (Andersen et al. 2012).

Although practicing level of LC is following the theoretical arguments with a lag, there are existing studies conducted to perform and measure the effects of LC applications. However, the results indicated in such researches may not be fully reliable. It is hard to quantify the role of the implementations over the achieved results due to the dependence of construction projects to external factors like geographical conditions, project types, applications of different tools. (Andersen et al. 2012).

Wright (2000) practiced expanding lean application to several projects to boost productivity and recorded involvement of more suppliers and the delivery of project for $3M despite its $4.5M preliminary budget. Salem et al. (2005) found more effective results than expected with last planner, increased visualization, daily huddle meetings and first run studies but the 5s process and fail safe for quality practices were not found meeting the expectations. Additionally, Rischmoller et al. (2006) implemented LPS and other LC techniques over one hundred construction projects in a five year term. Performance improvements from 7% to 48% in these projects were reported by eight different companies. Two more results were improvement reliability of planning and the possible contribution of IT tools for a more complete and standard LPS implementations.

Richard (2007), adapted Toyota motors principles by applying software to front end design to spot conflicts, used scheduling LP and selected subcontractors based on experiences. These helped them to satisfy the needs of client by $2 per foot less than planned budget and rewarded $50000 in change orders by avoiding conflicts.

Ballard (2008) examined the effects of Lean Project Delivery System (LPDS) in two different healthcare facility building projects. The results of the first project – Shawano Clinic - has shown that although target cost was set 3.6% below the benchmark, actual cost of the project was 14.6% below the target and 17.6% below the benchmark, moreover, the project was concluded 3.5 months before than planned schedule which generates 70 additional day's revenue for the owner which corresponds to $1 million. The second project was ARC for SR Medical Center and the Fairfield Medical Office Building. The target cost of the project similarly set

14.1% below the benchmark and the actual cost was calculated 5.3% below the set target cost.

Miletsky (2010) provided the involvement of workers with a three dimensional software with models, direct contact between management and instant location of worker issues and this resulted with a positive effect on workers and their morale which increases the efficiency of the work.

Garrett and Lee (2010) used Value Stream Mapping (VSM) and other various lean concepts and this brought the opportunity of eliminating part of the coordination effort. This is measured by the reduction in activities in the process from 8 to 5, decrease 40% lead time and process time 25%.

Yoders (2009) noted that when Building Information Modeling (BIM) used as a lean construction tool, a reduction of $3 Million recorded from estimated $286 Million target with the addition of reduced delivery time.

2.2.9 Lean Project Delivery System (LPDS)

A system developed, introduced and updated by Ballard (2008) named as Lean Project Delivery System. This system aims to build guidelines for the implementation of lean project management. LCI (Lean Construction Institute) defines main modules of Project delivery system containing lean design, lean supply, lean assembly, lean production and lean delivery system. Figure 2.1 illustrates the system, there are 13 modules in the system all of which interact and integrate through the whole construction process. The five phases in the system are named as project definition, lean design, lean supply, lean assembly and use. Production control and work structuring are two additional modules that are performed throughout the whole process. Although the system is not directly generated for construction industry, it is claimed that LPDS would be more productive for the projects that are complex, quick and uncertain, which are mostly valid for construction projects.

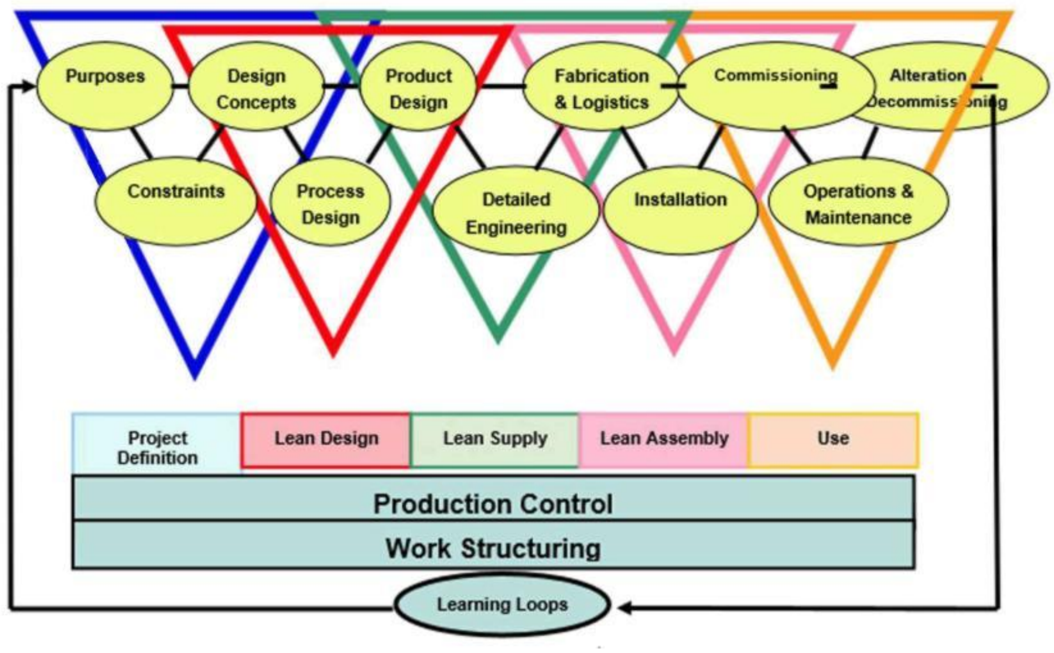


Figure 2.1 Lean project delivery system (Source: Ballard, 2008)

As seen from the figure, the project starts with a definition phase consisted up of purposes, constrains and design concepts. Next phase is lean design including design concepts, process design and product design. Then lean supply consists of product design, detailed engineering and fabrication and logistics. Later, lean assembly phase is performed by executing fabrication and logistics, installation and commissioning works. And finally, use phase is consisted up of commissioning, operations and maintenance and alteration and decommissioning.

According to Ballard (2008), in LPDS, the project is considered and constructed as a process for value generation. Stakeholders and suppliers of later phases are incorporated in planning and design works through cross functional teams. There is a continuous optimization effort to improve work flow for increased productivity. Managing material and information flow through related parties is performed with pull technique. Variability absorption is provided with capacity and inventory buffers and there are continuous improvement is advised to perform at every level of the project by feedback loops.

There is a consensus among the practitioners in the construction industry that performing is the best way to learn new techniques, that's why LPDS plays an important role by creating a practical guidance for the industry and awareness of lean culture (Al-Aomar 2012).

2.3 Design Management and Lean Design

A finding of the study conducted by El. Reifi & Emmitt (2013) points that the inefficiency in design stage rises up as deficiency during the procurement stage. In parallel, according to Sacks et al. (2009), the approach employed in the design process has effects over not only the design process but on the whole construction process.

2.3.1 Design – Design Management

Considering its connection with technology and engineering sides of production and manufacturing, design can be seen as a technical discipline while it is also possible to regard it as a social science with respect to the significance of user studies (both qualitative and quantitative) for the comprehension of the necessities which the product should meet. Moreover, it is possible to perceive design as a "form of art" by focusing on its power to communicate romantically with its user-audience with the expression it creates by form (Ordoñez & Rahe 2013).

A widely internalized framework of architectural design process is generated by RIBA (Royal Institute of British Architects). 8 work stages identified in the body of workplan as follows:

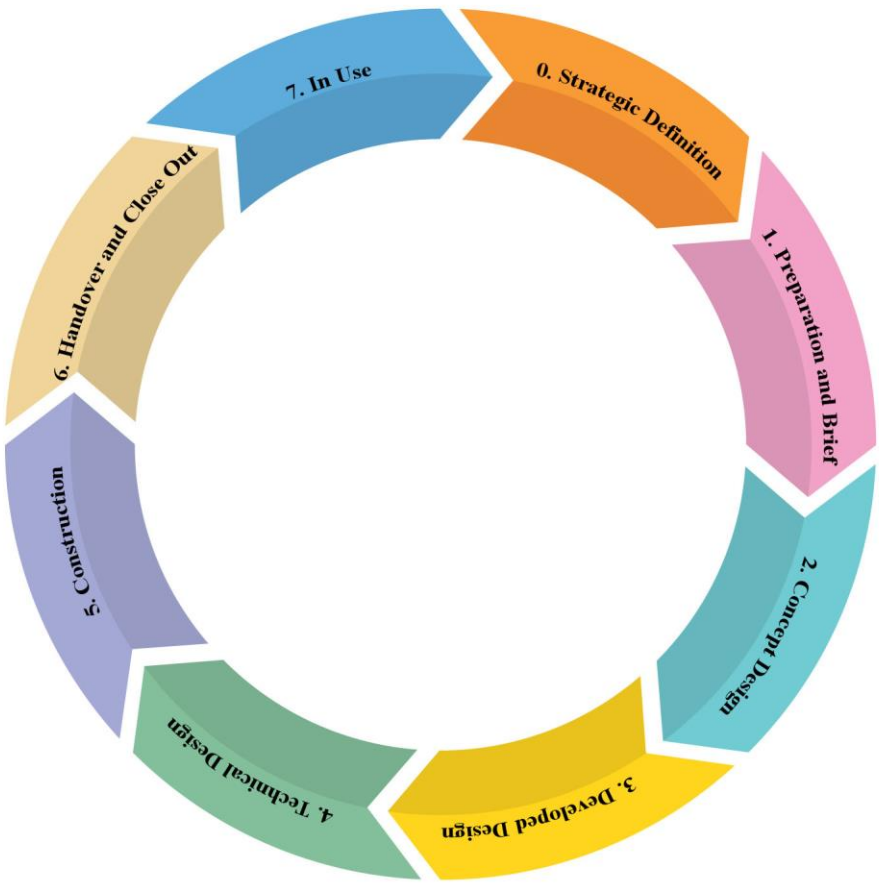


Figure 2.2 RIBA plan of work

Strategic Definition: Core project requirements are identified, project programme is established and strategic brief is shared. Project team is also initially considered.

Preparation and Brief: Project objectives (quality objectives, project outcomes, sustainability aspirations and project budget etc.) are developed, feasibility studies undertaken. Site information and project programme are reviewed. Initial brief is performed.

Concept Design: Conceptual proposals (including architectural and structural design, building service systems, outline specifications and cost information) prepared with relevant project strategies in accordance with design programme. Final project brief is issued after the alterations.

Developed Design: Proposals (including architectural and structural design, building service systems, outline specifications and cost information) are coordinated and updated in accordance with design programme.

Technical Design: Technical design is prepared (including all architectural, structural and building service information, cost information and specialist subcontractor design and specifications) in accordance with design responsibility matrix.

Construction: Offsite manufacturing and onsite construction are performed according to construction programme and design queries from site are responded when arised.

Handover and Close Out: Building contract is concluded with the handover of building. "As constructed" information is updated.

In Use: Services are undetaken according to schedule of services. "As constructed" information is updated in response to ongoing client feedback and maintenance or operational developments (RIBA 2013).

As Nicholson and Naamani (1992) stated, new difficulties for architectural designers has arised years ago due to the sophistication of building projects and the complexity of the professionals in the construction market and projects. The spread of clients' attention in a way including not only the project cost but also cost in use throughout the building lifecycle can be seen as the pointer for the value management concept in today's situation.

Austin et al. (2002) shows following issues as in the aims of efficiency increase studies: (1) exchanging the information between the design team and suppliers working about the fabrication activities throughout the whole supply chain; (2) evaluation of both traditional batch packets and progressive procurement methods and (3) improvement of decision-making and scheduling by identification of the process model and relevant analytical techniques. Understanding the processes of the designers has to be improved in conjunction with their roles and responsibilities within it. Moreover, contractors must have an improved understanding about design and its deep relationship with the efficiency of construction. It seems mandatory to integrate virtual shifts for reaching a collaborative and continuous improvement culture of right on first time.

2.3.2 Lean Design

Koskela et al. (2002) indicated that design phase generally characterized as the major source of the issues for following phases. High frequency of design changes – including client decision making - are main reason behind the transmission of the negative reflections which squeezes the preparation of procurement and construction.

Pasquire and Garrido (2011) defined value as the desire of customer regarding the product. They moreover propounded two concepts: first value is senior and expresses social objectives which are politically led and intangible, while last value represents the products and services which customers will pay for. The authors continue with the argument that although the first value is not necessary to be achieved by all projects, every of them should reach the last value.

Despite being possibly the most energetic, motional and creative aspect of any design project, the conceptual phase seems as like the least understood one. This is linked by the Austin et al. (2002) with the lack of understanding of the conceptual design process in part due to the diverse range of disciplines and perspectives involved.

The study conducted by El. Reifi and Emmitt (2013) reveals that, poor project design is one of the most frequent delay and budget overspend reasons in projects besides procurement methods, poor project management and inaccurate feasibility studies. There are existing inefficiencies in the design process both due to the nature of the process and the ways it is managed.

It is also placed in the literature with a consensus that a lean culture should become established within the structure of an organization before implementing its principles (Emmitt et al. 2012).

Possible developments progressed in design management can help to reduce the amount of waste produced both in design and construction of a project. Information modeling techniques are open to get adopted to contribute WM strategies (Baldwin et al. 2007).

All of the lean design management strategies should internalize the aim of maximizing the overall value for clients, end users and society with providing high level of performance (Emmitt et al. 2005). According to Jorgensen and Emmitt, the individuals involved in the process and their ability in lean implementation to various angles and projects affects deeply the application of lean. Most of the respondents in this study claimed that early design stages is the correct time to increase the value of the project, on the contrary, a few of them pointed out that if it was possible, more of extra time should be allocated to detailed design preparation. Because the real benefit will not be gained by spending more time for conceptual design. They add that the problem is not always about having adequate time for the design, because the available time is badly used generally. The important thing is the efficient management of the design stages at this point.

The design production sector objectives are settled as; to aid the identification of client's needs, adopt a common framework to improve design and construction management and aid technology information into design and construction management. (Austin et al. 2002)

2.3.3 Transformation - Flow - Value Theory

There are three main principles of production Management were addressed by Koskela (2000) in the body of TFV theory: transformation, flow and value. The theory accepts production processes as a value generation system consists up transformation and flow sets. The efforts for increasing the efficiency level of design phase can be grouped under these three groups.

Koskela et al. (2002) rendered the design process in three different lines; (1) transformation of inputs into outputs, (2) information flow within time and space and (3) value generation process for customers.

Table 2.2 Transformation, flow and value generation concepts of design (source: Marhani et al. 2012)

	Transformation Concept	**Flow Concept**	**Value Generation Concept**
Conceptualization of design	As a transformation of requirements and other input information into product design	As a flow of information, composed of transformation, inspection, mocing and waiting	As process where value for customer is created through fulfilment of his requirements
Main principles	Hierarchical decomposition; control of decomposed activities	Elimination of waste (unnecessary activities); time reduction, rapid reduction of uncertainty	Elimination of value loss (gap between achieved value and best possible value), rigorous requirement analysis, systematized management of flow down of requirements, optimization
Methods and practices	Work Breakdown Structure, Critical Path Method, Organizational Responsibility Chart	Design structure matrix, team approach, tool integration, partnering	Quality Function Deployment, requirements management, value engineering, Taguchi Methods
Practical contribution	Taking care of what has to be done	Taking care that what is unnecessary is done as little as possible	Taking care that customer requirements are met in the best possible manner
Suggested name for practical application of the concept	Task management	Flow management	Value management

It is vital to understand the every element of value concept for the special case because minimizing waste is not always a guarantee for the overall success of a project (Emmitt et al. 2005; Thyssen 2011). Value can vary with the client, organization and project. Client value can be cost, time, function, sustainability or aesthetics while organization value can be time, profit, repeat business or being well known. According to study, comparing work productivity with efficiency can be seen as the most determinant parameter to measure the value performance (El. Reifi & Emmitt 2013).

- **Transformation**

Transformation view has dominated practice and science through major part of 20th century. This view understands the production as a transformation of inputs into outputs, but not focused the process deeply. Work breakdown structure is reached as the effort of production management by breaking down the total transformation into smaller transformations, tasks and activities (Koskela 2000). Transformation concept believes that the cost of total process can be minimized by minimizing the cost of each independent sub-process. The value of output is directly associated with value (or cost) of inputs of the process.

Lack of systematic planning and deficient specification of tasks and responsibilities reduces productivity and quality in design and subsequent activities as well **(**Koskela et al. 2002).

- **Flow**

Being different than transformation, flow view focuses on what is happening between the transformations. The concept includes waiting, inspection and moving stages in addition to transformation phases so time is an important aspect. The activities were divided into two as value adding and non-value adding and it is aimed to decrease unnecessary non-value adding activities. Shingo (1989) accepts inspection, waiting and movement as non-value adding activity and therefore considers them as waste.

Recognition of non-value adding activity brings the idea of process development by eliminating them. Reducing lead-time and variability, simplifying, increasing flexibility and transparency in the process are determined as the ways for reducing such waste (Koskela 2000).

- **Value**

Value concepts directly orientate the process towards the needs of the client. Value can be seen as what customer accepts to pay for. Main aim is to increase the customer satisfaction. Some sacrification can be involved in the process for the benefits. The difference between maximum possible value and generated value is questioned and the effort is spent for decreasing the gap (Marhani et al. 2012). A successful value generation requires a well-structured client-producer relationship from the beginning of the process. Customer needs should be clearly understood and best possible actions should be considered for maximizing the benefit of the product with minimum amount of sacrifice in the process.

2.3.4 Design Management Problems

The problems addressed by researchers in previous studies were briefly mentioned under this title. The problems may be sourced from the transformation itself, flow process and even from the value understanding of design management approach. Some of them only pointed out the problem while some recommended solutions.

The reasons of rework are mostly associated with design development phase in a project which may be concluded with delay, budget over-runs and less value being delivered to the client. The other contributing phases were shown as design brief, concept design and technical design (El. Reifi & Emmitt 2013). Moreover, last minute re-designs, inefficient flow of information, overly complex designs, problems regarding obtaining town planning permission and compliance with regulations had been shown as poor design management factors.

Unprepared image of the participants in the design meetings has been seen as a problem by Koskela et al. (2002). It is also noted that there is a lack of clear roadmaps for next phases and all the outputs could not have been presented at these meetings. Unprepared decisions made without reaching enough level of relevant information with surveys and investigations. Moreover, the decisions made were not remembered always in next meetings. Unclear responsibilities of different disciplines can be seen as a reason for the situation.

Unnecessary rework addressed by Koskela et al. (2002) as an important waste type in construction design. Two main reasons are highlighted for unnecessary rework: first;

design tasks are not always clarified and ordered efficiently at the beginning. Secondly, even if the order is well established, there are factors forcing the plan to get away from ideal range. As a result, design tasks generally suffer from lack of information.

According to Josephson and Hammarlund (1999), the defects caused by design process form the largest category when measured by cost. Furthermore, it is indicated that the defects originated from lack of coordination between different disciplines constitute biggest category of design based defects. Similarly, Lyren and Sundgren emphasized lack of communication and coordination between designers and weakness in definition of required time for tasks and phases among the problems of design management (cited in Koskela et al. 2002). Sverlinger indicates that efficient planning and resource allocation, deficient input information and changes are the most frequent causes of great refractions in design process (cited in Koskela et al. 2002).

The problem of reaching information about the past and progress of actual projects is pointed by Austin et al. (2002). It is said that the information should be stored and referenced for easy access to ensure the related information is not dropped beneath the radar. Furthermore, IT Technologies are implied for information storage and referencing. These tools are specialized for (1) setting the references between documents, (2) establish indexes of data (3) search engines and list generators about a specific topic and (4) create sections and documents to be referenced. Similarly, Tribelsky & Sacks (2011) claim that the waste can be reduced and value can be improved by design managers with focusing on the information flow and information share characteristics.

Furthermore, lack of efficient information flow leads to generate waste in design process. Tribelsky and Sacks (2011) emphasized the importance of information for designers by positioning it as the raw material of the process. Consequently, unstable flow of information means unpredictable results of the project process. To illustrate, when new information is untimely available, there may be necessity for rework, moreover designers may focus on other jobs on their board while waiting for further information.

Better integration of project processes is vital to achieve the efficient outcomes from project and it is required not to consider the design and construction process separately (El. Reifi & Emmitt 2013).

Insufficient guidance and support for clients, problems in capturing needs of clients and delivering different conceptual design options to them and finally the lack of common language between the clients and designers preventing communication and information flow between them are addressed as main problems faced in construction briefing. Different sides involved in briefing are generally geographically distributed and working for different organizations. Because briefing stage is determinant over the total cost and work programme, the decisions given should be monitored and their impact should be traced correspondingly (Austin et al. 2002).

Nicholson and Naamani (1992) pointed out that some possible external forced alterations on projects such as clients' budget revisions, market condition shifts and conditions imposed by the regulator authority. This can be seen as inevitable, but the authors also remark that there are alterations which are not inevitable, especially the ones related with a clear initial brief. Furthermore, Lindkvist (cited in Koskela et al. 2002) found five main problems related to client decision making; (1) late involvement of decision makers and short duration allocated for Project, (2) resistance of decision makers to get the importance of determine and express what they want, (3) the urgency of the situation leaves no room for developing alternative proposals, (4) insufficient amount of time allocated for methodical programming, (5) difficulty for the client to ensure that various requirements are transparently transferred to the project.

It is indicated that nearly one third of the external alterations affecting design process were sourced by the client or Project management (Sverlinger, cited in Koskela et al. 2002). Barton (1996) claimed that cost, quality and appropriateness for purpose problems caused by the conceptualization and initiation processes which can directly linked with the insufficient briefs. Lyren and Sundgren (cited in Koskela et al. 2002) linked the design improvement level directly to the clients' ability to express their requirements explicitly.

Overabundant expectations and requests of clients contribute to deficiency in the scope of the project. Their too much rashness for starting the project push the design and construction team to start the job without clear planning considerations. Consequently, they fail to make correct decisions and this situation leads to late approvals and communication problems (El. Reifi & Emmitt 2013). Early design stage widely suffers from the factors related with the significant lack of clarity about realizable advantages which could be consolidated from the investment of the client. The clients reviewed as defective in understanding possible complete results of an alteration during design stage (which even may result with complete redesign), having no understanding regarding the commissioning process, (leaving everything to the last minute), having no background experience about what they are commissioning and not following the consultants.

There are factors related to design organization leading inefficiency; the ignorance of the brief by the designers lead them to be called back and rework the design in a relatively small amount of time after the client realizes the insufficient design (El. Reifi & Emmitt 2013). Some of the respondents in same study defended that a fixed briefing should be remained to reach a successful design because solid bases and clear requirements of client is vital for the rest of the process. On the other hand, there is a view supporting that a continuous briefing process may lead to errors on some of the early key issues. At this point, it is noted that "inexperienced clients can be trapped by their own decisions". Moreover, it is the designers' responsibility to help client under these circumstances and ensure that reliable decisions made. Waste generated due to client complexity is possible to be eliminated through workshops and collaboration, preferably by interviews and modeling. It is noted that organizing briefing sessions according to the development level of the design after a clear initial design brief performed to start the project in a strong way. The idea behind this suggestion is the belief that it is needed to freeze the information at the determined project milestones. The result of the study revealed that the freeze phases also have been seen as measurement and change management opportunities. At this point, it is required to mention the concepts which help to comprehend the requirements and desires of clients by enhancing the communication: value management (VM), quality function deployment (QFD) and client requirements processing model (CRPM). Freiré and Alarcon (2002) suggest using a systematic approach by integrating these tools at a strategic level as a solution in place of using one of them to cope with a determined characteristic of the problem.

2.3.5 Design Related Lean Principles

Liker (2003) introduced four main principles for lean: philosophy, process, people and partners and problem solving.

Sacks et al. (2009) derived principles of process from two concepts: flow and value. As quoted from the authors:

"Reduce variability, reduce cycle times, reduce batch sizes, increase flexibility, select an appropriate production control approach, standardize, institute continuous improvement, use visual management, design the production system for flow and value, ensure comprehensive requirements capture, focus on concept selection, ensure requirement flow-down, verify and validate, go and see for yourself, decide by consensus & consider all options and cultivate an extended network of partners."

2.4 Inferences Drawn From Literature Review

Through the literature review, it was observed that there are various studies conducted to make a contribution for the construction industry by increasing its efficiency. Waste management studies, generally mentioned in the beginnings of the literature review, focused mainly on the material waste. The most important inference used in this study is that the best waste management strategy is to prevent its generation. Moreover, these studies show possible major effects of design process over the construction phase in terms of material waste prevention.

However, the understanding of lean thinking is different than most of the researchers focused on material as the waste. Lean thinking names all inefficiencies in the process as waste. All non-value adding works during production are considered as waste according to lean construction. It is also claimed by literature that design phase is crucial for achieving a lean construction process. It is understood that steps taken for increasing lean maturity in architectural design will have positive impact over the efficiency of design, construction and further possible (operation *etc.*) phases of projects.

It is possible to observe the domination of construction phase focused studies on lean literature. The works dealing with lean design & design management emphasizes the relationship between different unique tools and their impact over the efficiency of architectural design implementation. However, there is a lack discovered in lean literature focusing on increasing the efficiency of whole architectural design process. As the first step of developing a lean implementation framework for architectural design service, this research aims to contribute for filling the gap by determining lean waste items enhanced in the practice of architectural design and discuss of their impacts over different project value parameters. By this manner, it has been seen possible to specify the priorities of industry for achieving a lean implementation roadmap. It is considered that the increase in efficiency of design process will have positive effect over the value parameters of construction and whole project process accordingly.

CHAPTER 3

MATERIAL AND METHOD

This chapter contains information about the material and methodology had been used to direct the research study. Firstly, the research framework and the reasons and selection criteria of the methodology is introduced. Following that information about sample selection, implementation of methodology, and finally, the results and findings of each procedure will be explained and discussed step by step.

The literature review on lean thinking and lean construction shows that the relationship between lean thinking and (architectural) design processes were overlooked despite their significance over the efficiency of actual construction processes. At this point, observation on design industry has obviously shown that there are inefficiencies to be eliminated and the whole value of the project development process can be increased. This has been seen possible by a lean thinking adaptation for architectural design industry particularly. After the review conducted in the lean related literature, the absence of a lean implementations oriented guide for designers in construction industry is confirmed and directed the further material generation for the study.

Although there are various tools and procedures argued for creating solutions for specific problems, none of the studies in the literature deals with the inefficiencies of architectural design process adequately for the industry. In the structure of this study, the construction projects is considered as a whole process containing the design phase in its body along with other phases. With the knowledge obtained from the literature about the difficulties existed due to the effort for solving the problems about waste on-site, the importance of lean decisions on the design phase was recognized and it has been seen as a necessity to manage design stage efficiently for the success of both the design and construction phases. That is why lean design is considered as a part of lean construction, thus as many dimensions as possible will be investigated in the study to help increase the efficiency of the whole construction process.

As stated before, increasing lean design maturity level is vital for increasing the efficiency of the whole construction process. The lean literature points at the first step, as the identification of the inefficiencies standing as bottlenecks in architectural design process. The aim of this study is to investigate and determine "Lean Design Waste Items" and examine their frequency of occurrence and influence over value parameters of the project. By obtaining such information, it is predicted to have a "Lean Design Waste Item List" with influence magnitudes for each item. That is expected to be a pathfinder for the industry to understand its weak points and work for progress in such areas to increase the efficiency of whole construction industry.

The research is developed in three steps as shown in Figure 1 to achieve lean design waste items list and specified parameter values for each item.

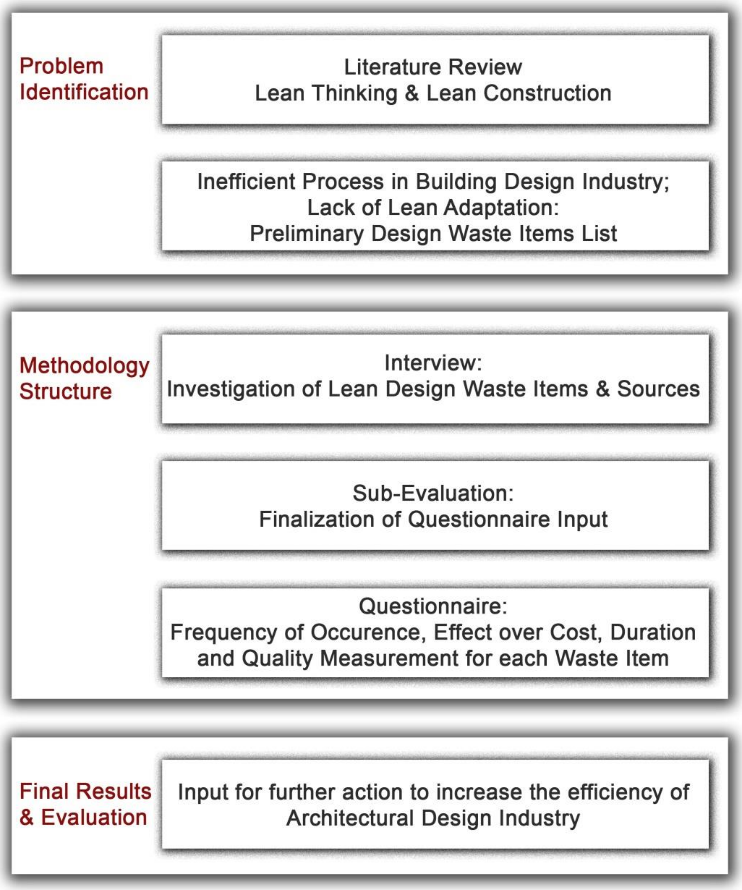


Figure 3.1 Research framework

As the first step for achieving lean production in architectural design processes, a series of "semi-structured interviews" were conducted to determine waste items. Then, interviews were evaluated and sources of design inefficiencies were listed as 28 waste items and classified under “8 Waste Categories”. Deriving from the interpretation of the interviews, 28 waste items were identified and became input for the next following step, namely, “questionnaire”. In the questionnaires respondents were presented with waste items determined during the interviews and requested to provide their views on the probability of occurrence, effect over cost, effect over duration and effect over quality for each waste item.

In final results and evaluation phase, the results of the interview and questionnaire are explained together and evaluated accordingly.

3.1 Grounded Theory

The approach of grounded theory was internalized to base the results of the study directly on the opinions of professionals from the industry with minimum subjective contribution of researcher.

By the term grounded theory, it is meant that a theory comes out from the data itself which has been systematically collected and analyzed via research process. There is a strong interrelationship between the data collection, data analysis and final theory trio in the structure of the method. There is no predefined theory in researcher's mind before beginning the study. Instead, the researcher specifies the area to begin the study and allows the theory to be manifested from the data. The argument is that the theory derived from the data is closer to the reality rather than the one derived by putting together an array of conceptual experience or only by fiction. Moreover, it is said that because the theories grounded from data are open to propose inner vision, increased understanding and sensible guide for further action (Strauss and Corbin, 1998).

The dignity of grounded theory comes from its capability not only to generate a theory but also base that theory on data. According to Peshkin (1993), theory building is not the main aim of all the research projects, nor should it be.

3.2 Interview - Lean Design Waste Items and their Sources

In order to obtain the input data required for questionnaire generation, a series of interviews were executed with professionals from Turkish architectural design sector. Main aim of the interviews was to reach a lean design waste items list. The waste concept referred in this section obviously internalizes the waste definition of lean thinking.

It was chosen to conduct the interviews with experienced and skilled professionals. Conducting interviews with a limited number of experts was preferred in this phase due to the necessity of:

- obtaining the opinions of qualified individuals from competent and relevant perspectives;
- covering the inefficiencies of design industry in depth;
- information providing about lean concept, its waste definition and 8 waste categories before having their opinions for adaptation; and
- clarifications for answers of open questions to be understood efficiently.

3.2.1 Sample Selection

The phase was conducted by executing;

- semi-structured;
- two way communication involved;
- open-ended questioned; and
- non-linear interviews

with the owners and managers of architectural design offices performing for at least 10 years in Çankaya province of Ankara, Turkey. A letter of proposal for interview including the information about the content, progress, and aim of the study, the university, the content and phases of the interview and the predicted duration -45 minutes- of the interview were sent to the interviewees in advance. Due to time limitation and busy schedule of possible respondents, the interviews were conducted in next step with 8 interested respondents out of total 23 reached.

3.2.2 Structure of Interview

The interview has covered three main sections; (1) professional - personal data collection; (2) informative part - lean presentation; (3) 8 wastes adaptation for lean design.

In the first section, a series of questions were directed to the participants related to their organization, position in the organization, number of years their organizations were performing in the industry, number of years they were performing in the industry, the project types that their organizations were working on, average completed work amount of their organization and number of employees within the organization.

To avoid the possibility that the interviewees have no or limited knowledge about the lean concept, a "lean production and 8 wastes" themed informative presentation was made prior to probing their opinions in second section of interview. The informative part of presentation was designed for explaining aims of lean production, value concept, waste concept, and the particular aim of the interview and the study briefly.

In the third and final section, explanation of "8 Waste Categories" was provided as a continuation of the presentation. Each waste category was placed in one slide accompanied with an illustrative schematic video, examples and possible reasons of them and after the explanation is finished, the opinions of the interviewees were asked about the projections of the waste category in question over the architectural design production process. The respondents were expected to express their thoughts, experiences and problems they faced with about the illustrated waste category. Owing to the lean presentation made in second section of interviews, the interviewees were capable of understanding lean waste concept and project their opinions about the inefficiencies that can be addressed as lean waste in the process. The conversations were recorded in writing.

Maximum care has been taken in order not to have an influence over the ideas of the participants. Although a preliminary design waste items list had been obtained before the interviews, no information was given about them unless the conversation had stalled. In those situations, information related to the preliminary waste item list was given as a probe to open the conversation up and make the information flow continue. This procedure is followed to have the information directly from the sources with no guidance over the opinions. This is vital because the output of the interview has been used as input of the questionnaire implemented as a further step.

In brief, it can be said that although interviews do not have the opportunity to gather information with 100% objectivity, because there was no preconceived opinion to be stuck with about the lean waste items and their sources, maximum sensitivity was shown during data collection and analysis processes of interviews to reach absolute objectivity.

Lean design waste items and their sources for each lean waste item were the core output of the interviews. However, the participants of the interviews were not requested to comment on the frequency and effect of those waste items. The reason was that whole series of interviews had to be completed before having a better picture of entire waste item list. The list was obtained after finishing all the interviews and evaluating the information.

3.2.3 General Remarks from Interviews

Before evaluating the statements of interviewees in terms of 8 categories of lean wastes, this section includes general remarks and opinions of interviewees regarding actual architectural design process. Although the views quoted in this part of the study cannot be directly placed under any of the categories listed in next section, they may be instructive to understand the current architectural design practice and the main problems that architects have to deal with.

To begin with, all of the respondents complained about the attitudes of clients towards the design process. Their impatience was given as the reason for inefficiencies in the sector. Respondent H stated "product of design process is just seen as a document that is compulsory for construction to begin." Similar comments were received from other respondents. Respondent D noted that the ignorance of clients about design work make them less respectful with the work that would normally be performed together. At this point the requirement of a well-planned briefing is emphasized for a well-organized architectural design process. By considering design as a mechanism to be operated in cooperation between the designer and client, problems sourcing from clients play an important role in waste generation.

Another prominent topic mentioned during the interviews was the public administrations and their attitude as a major source of inefficiencies in design industry. All of the respondents gave examples of such problems. Related inefficiencies are placed under relevant categories in next section; *i.e.*, the use of FIDIC contract types, requesting qualification instead of lowest price and seek for a transparent process in public tenders were suggestions made by the respondents at this point.

The initial sources of wastes addressed by designers were belonging to parameters that are not relevant to running process of architectural offices. They generally targeted other stakeholders in the industry. On the contrary, the respondents mentioned about the in-house problems and their possible sources after a while spent with the evaluation of lean waste definition and categories. The reasons for all the waste items are mentioned in next section.

One of the main points that most of the respondents have agreed was that Lean Production Wastes and Principles were not 100% adoptable directly as like any other production industry due to the distinctive nature of architectural design practice. When compared to other production design industries, building design has too many decisions for each product since each building project is a unique, one-off undertaking. In other words other industries may have the chance to have a production line after the design is finished, to manufacture a great number of that product. On the other hand, although there may be some similarities during the application of the production on the site, in the end of the day each design is generated only for one final product in construction industry. That may be illustrative to understand why there was not enough number of studies on the relationship between lean production and building design industry. This was exactly the point for conducting these interviews to collect the opinions of the manager designers about the process wastes. The gathered lean design waste items can be found in Table 3.1 for a general view of interview results.

3.3 Wastes Classified Under 8 Categories of Lean

In this section of the study, the information gathered from interviews are evaluated under 8 Waste Categories. Some of the items may be repeated by different respondents, but in order to involve an item in the list, it was enough to be said at least once by one of the respondents. The aim is to collect all the possible items without considering the greatness of their impact or their probability of occurrence because these parameters were already planned to be inspected in the next phase of the study by questionnaire over a wider population. In next phase, Lean Design Waste Items will be explained under 8 Waste Category titles. Each title includes essential parts to be highlighted from the information recorded in interviews and at the end of every category title, tables can be found showing relevant waste items and their sources declared by interviewees.

Table 3.1 Design waste items under 8 waste categories

1.Overproduction	
	Undelivered production
2.Defects / Correction	
	Production of defective technical drawings and details etc.
	Revision works according to data provided from other disciplines
	Explanation requirements (unfinished works)
	Architectural decision alterations
	Compliance to regulations
3.Waiting	
	Waiting for information from other disciplines
	Protracted previous works
	Late information from client
	Waiting for stationery, print and model works
	Discontinuation in the project
	Relationship problems with public administration
4.Motion	
	Works/actions performed for providing site information
	Works/actions performed for providing presentation - design materials
	Works/actions performed for providing reference technical information
	Inefficient meeting organizations
5.Inventory	
	Ineffective use of qualified source
	Work finished earlier than required
6.Overprocessing	
	Rework
	Low speed working
	Ineffective employee performance
	Unqualified data from other disciplines
	Ineffective – unnecessary information exchange
	High expectations from unqualified sources
	Incapability to have institutional habits
	Problems with client relations
7.Unused Employee Creativity	
	Unused employee creativity
8.Transportation	
	Unnecessary transportation processes

3.3.1 Overproduction

As mentioned before, due to the special situation of the industry, an overproduction in the manner that in production line is not seen possible to face with in architectural design process. However, most of the respondents interpreted the "overproduction" concept as the "generation a product that will not be delivered to customer". And right after making such a description, Respondent A and C stated that this kind of an overproduction was faced frequently. On the other hand, Respondent A stated that although the overproduced work could be thrown away, sometimes it was seen as research and development activity to be used for possible future projects. However, it can be said that even it will be used for another project, the timing may obviously not proper for a research and development activity in detail production phase of a project. Respondent B remarked the unawareness of designers about low cost detailing solutions causing the products not to be used on site. Respondent D mentioned about creation of insufficient preliminary projects that do not answer the needs of client that causes to spend time for an imaginary project that will not be put into practice. Respondent E and H highlighted the unclear and changeable client needs as a source for overproduction while Respondent F holds ill planned design process as main responsible for it. Respondent G states that being obliged to jump into next step before finishing predecessors increases undelivered production in architectural design works.

Table 3.2 Overproduction waste item and sources

Undelivered production	
	stakeholders not being 100% aware of the client needs
	changing decisions belatedly to reduce the cost
	designers not caring the application problems/cost
	trial and error based production method due to the nature of design process
	the change of client needs
	the difference of value concept for the designers and the client
	production of ineffective preliminary projects
	ineffective inspection of documents
	to be obliged to jump to the next step before finishing predecessors
	insufficient information sharing from architects
	not use of written documents for decisions and ineffective feasibility studies
	waste accepted as inevitable
	ineffective controlling and monitoring of process

3.3.2 Defects / Correction

All of the respondents agreed that this category of waste is occurred too often. Name of the waste category - defects and correction - was obvious enough for respondents to understand directly from title. So they easily listed relevant inefficiencies and their sources in the process.

Interdisciplinary revision works and the pressure for jumping to next phase before finishing previous one 100% were the most emphasized sources for the category. Although similar answers were given by most of the respondents, Respondent A attracted the attention to inability to decide all necessities on the required time. Respondents B and D emphasized explanation requirements as a source of correction works when Respondents A, F and H mentioned inability to provide employee continuity. Respondents B and C addressed defective architectural decisions of designers. Besides, Respondents B, D and E stated that to professionalize on a specific task - *i.e.*, project type - increases the efficiency, on the other hand, Respondent D noted that "every project is a unique adventure" so it is impossible to have a 100% domination over the process. Respondents A and E suggested to create a checklist for minimizing explanation requirements and correction works. Concordance to regulation works referred by Respondents D, E and H. Moreover, Respondent F emphasized unawareness about the qualifications of sources leads to defects and corrections. The pressure over the designers for working rapidly causes inefficiencies according to Respondents G, H and B. Inability of co-operation between all the disciplines from commencement of the project is denoted by Respondents G and H. In Addition, architects' lack of knowledge about the buildings' function and operation and site applications is noted by Respondent H as one of the main reasons for defects and correction works in architectural design industry.

Table 3.3 Defects/correction waste items and sources

Production of defective technical drawings and details etc.	
	clients' rash to start construction
	unawareness of the employee about his/her own qualifications
	inability to provide employee continuity
	employees not feeling as an important part of the organization
	lack of self-evaluation of the organization
	hardness to professionalize on a specific task
	architects' lack of knowledge about the buildings' function and operation and site applications
	unwillingness to allocate sources for new attitudes
Revision works according to data provided from other disciplines	
	lack of self-evaluation of the organization
	inability of co-operation between all the disciplines from commencement of the project
	desire of client to work with a particular engineering team
	jumping to next phase before necessary information reached from other disciplines
	not following innovations in the industry
	stakeholders' lack of core knowledge about different disciplines
Explanation requirements (unfinished works)	
	unawareness of the employee about his/her own qualifications
	lacking self-evaluation of the organization
	waste accepted as inevitable
	hardness to professionalize on a specific task
	ineffective controlling and monitoring of process
	positive attitude towards "correction in-situ"
Architectural decision alterations (defective architectural decisions)	
	architects' lack of knowledge about the buildings' function and operation and site applications
	hardness to make decisions on time due to untimely arranged requirements of clients
	hardness to professionalize on a specific task
	insufficient architectural feasibility studies
Concordance to regulations	
	not producing regularity complied drawings in first time
	unawareness of the employee about his/her own qualifications
	inability to provide employee continuity
	unexpected changes in regulation, zoning status, etc.

3.3.3 Waiting

Waiting was another easy to understand and interpret waste category that can directly be experienced in architectural design industry. Being similar with the previous category, all of the respondents stated that waiting was faced very frequently.

All of the respondents addressed late information from client as a waiting source that can be occurred due to ineffective management and delayed decisions of client. Respondent A declared that it is not easy to schedule project duration because of unclear problems in the process. Long approval processes addressed by respondents B, C, D, E, F and G; changeable decisions and unpredictable working style of local administrations were added by respondents B, C and F. Another source that all of the respondents agreed is waiting information from other disciplines. It is noted that revisions leading new revisions in another discipline increases the waiting risk in the process. Respondents D and F mentioned unbalanced organization plan of design process and insufficient feasibility studies. Respondents E and G referred to multiple clients and funding problems as other main sources of waiting. Protracted previous works especially obtaining site and other relevant documents were pointed at by Respondents F and G.

Table 3.4 Waiting waste items and sources

Waiting for information from other disciplines	
	ill-planned organization of the process
	unpredicted problem of stakeholders (to be as fast as slowest one)
	the desire of client to work with a particular engineering team
	unwillingness to allocate sources for new attitudes
	ineffective controlling and monitoring of process
Protracted previous works	
	phase waiting for lacking information
	waiting for obtaining site document
	ill-planned process organization
	ineffective controlling and monitoring of process
Late information from client	
	ineffective direction of client
	waiting for approval processes
	delayed decisions of client
	multiple clients
	insufficient feasibility studies
	client not paying enough attention for project phase
Waiting for stationery, print and model works	
	waiting for unpredicted technical problems
	ill planned process organization
Discontinuation in the project	
	waiting for approval processes
	unpredicted alterations in regulation, zoning status etc.
	financial problems of client
Relationship problems with public administration	
	waiting for approval processes
	problems about public funds in public projects
	frequent personnel changes in especially local administrations

3.3.4 Motion

By considering the fact that architectural design production has particular considerations when compared to other production industries, motion is evaluated as unnecessary mobilization of designers and other sources and not being able to create value for the process and the customer. By looking from that angle, four major waste items can be compiled from the statements of 8 respondents.

Respondents A, D, F, and G addressed unnecessary mobility works for obtaining required site documents as a source of motion waste by adding the discordant working style of different administrations as the main reason for that. Respondents A, B, D, E, F, G, and H have all noted that inefficient meeting organizations create motion. Frequently organized meetings with excessive number of participant and reversely, lack of participation of relevant and necessary professionals were both referred by the respondents as the reasons of inefficient meetings. Furthermore, Respondent A stated "We cannot perform the actual job because of frequent meetings". Likewise, Respondent B noted "The more meetings organized, the less amount of work performed". On the other hand, Respondent C claimed that the meetings were helpful for reducing the duration of project. Respondents A and F also emphasized works and actions performed for providing presentation and design materials such as printings, models, stationery issues *etc*. Moreover, Respondents D and F mentioned works performed for providing reference technical information; irregular structured form of CAD blocks library and insufficient institutional CAD library could both be reasons for motion waste accordingly. Respondent D also noted that this kind of an effort can also be seen as research and development activity, so it cannot be seen as a waste item directly.

Table 3.5 Motion waste items and sources

Works/actions performed for providing site information	
	high number of documents required to start a project
	discordant work of different administrations
	diversity of data provider organizations
	unpredictable working style of certification authority
Works/actions performed for providing presentation - design materials	
	ill-planning of providing print and model etc. materials
	unsuccessful management of documents and consumable materials
Works/actions performed for providing reference technical information	
	irregular structured form of blocks and library
	insufficient institutional library
Inefficient meeting organizations	
	frequently organized meetings with excessive number of participant
	lack of participation of relevant and necessary professionals
	unwillingness to allocate sources for new attitudes

3.3.5 Inventory

"Because the information is stored on digital environment, there is no inventory problem." That was the first reaction given by most of the respondents to the title of the waste category. However, after thinking over the lean definition of inventory waste, the attitudes of respondents have changed. By considering it as "keeping and storing qualified source and product without gaining any benefit from them", two major waste items were formed up by the explanations of respondents.

Ineffective use of qualified source is described as a frequently encountered waste item by respondents but they have addressed different sources. Respondent A emphasized inability to provide employee continuity, "waste is inevitable" perception of designers and ill-planned institutional spending. Respondents C and D agreed with Respondent A that lack of in-house technical education is a major source of ineffective use of qualified source in architectural design industry. Finally, insufficient feasibility study was addressed by Respondent D. Another major waste item noted by respondents was work finished earlier than required. Respondents F and H claimed inexperienced employee, production of further detailed drawings for the phase requirements and ineffective controlling and monitoring process may be the main factors contributing to finish work earlier than required. Respondent E is agreed with F and H that "insufficient feasibility studies" is also a reason. Finally, Respondents D, F, G and H together charged ill planned design process accordingly.

Table 3.6 Inventory waste items and sources

Ineffective use of qualified source	
	inexperienced employee, insufficient feasibility study
	lack of in-house technical education
	ill-planned institutional spending for software, hardware etc. sources
	unawareness of the qualifications held
	insufficient authority sharing
	waste accepted as inevitable
	inability to provide employee continuity
	not following the innovations on the industry
	unwillingness to allocate sources for new attitudes
Work finished earlier than required	
	ill-planned design process
	inexperienced employee
	insufficient in-house technical education
	insufficient feasibility studies
	production of further detailed drawings for the phase requirements
	hardness to reach process information
	ineffective controlling and monitoring of process

3.3.6 Over-processing

Over-processing was the category that emerged the highest number of waste items. This was found comprehensible by considering every project is a new and unique process requiring high number of decision making. 8 major waste items has appeared in this waste category.

Respondents A, C, and E attracted the attention to ineffective employee performance resulted from inability to create employee continuity. Respondents A and B mentioned they were suffering from unclear objectives of client. All the respondents stated that there is a high amount of rework existence in the process. Respondents A and G addressed to be obliged to continue production without having all relevant decisions. Respondent A added insufficient guidance by laws and problems with client relationships. All of the respondents noted that ill-planned design processes lead to over-processing. At this point Respondent B suggested a checklist application in order to reduce the over-processing in design process. Inefficient performance of employees were referred to by Respondents B,C, D, and E. Respondents C and F claimed low speed working and ineffective and unnecessary information exchange are causing over-processing. Respondents C, H and E emphasized unqualified data from other disciplines and the importance of stakeholder selection. According to respondents C and H, incapability of having institutional habits and hardness to professionalize on a specific task are other reasons for inefficiencies. Respondent D, emphasized the rashness of clients to start construction and the importance of being aware of the source qualifications once more at this point. Respondents D and E denoted having high expectations from unqualified sources mislead the process and causes over-processing. Insufficient feasibility studies and architects' lack of knowledge about the buildings' function and operation were referred by Respondents C, D, F, G and H. Finally, the necessity of using, claiming written documents for decisions was deeply emphasized by Respondents G and H.

Table 3.7 Over-processing waste items and sources

Rework	
	unclear client desires
	inability to provide employee continuity
	insufficient feasibility studies before beginning of the project
	not use of written documents for decisions
	waste accepted as inevitable
Low speed working	
	ill planned process organization
	the expectation of operating feasibility studies from architect
	lack of in-house education
	negative effect of the working environment over the motivation of employees
	excessive number of stakeholders in the process
	unwillingness to allocate sources for new attitudes
	hardness to professionalize on a specific task
	ineffective controlling and monitoring of process
Ineffective employee performance	
	inability to provide employee continuity
	unawareness of the possessed source quality
	negative effect of the working environment over the motivation of employees
	concentration problem
	hardness to professionalize on a specific task
	unawareness of the employee about his/her own qualifications
Unqualified data from other disciplines	
	unnecessary data interchange
	insufficient information sharing between stakeholders
	not use of written documents for decisions
	ineffective controlling and monitoring of process
Ineffective – unnecessary information exchange	
	lack of planned brief by designer
	Incorrect and unclear input from client
	inability to provide employee continuity
	insufficient guidance by laws
	ill-planned design process
	unfavorable requests of public administrations
	ineffective meetings
	lack of written documents for decisions
	excessive number of stakeholders in the process
	ineffective controlling and monitoring of process

Table 3.7 (continued)

High expectations from unqualified sources	
	insufficient software, hardware etc. Source support
	not following the innovations on the industry
	ill-planned design process
	commence of project without effective feasibility study
	unwillingness to allocate sources for new attitudes
Incapability to have institutional habits	
	inability to provide employee continuity
	insufficient guidance by laws (excessive gray area)
	lack of self-evaluation of the organization
	insufficient authority sharing
	lack of clear job definition
	not use of written documents for decisions
	waste accepted as inevitable
	lack of in-house education
	hardness to professionalize on a specific task
	unwillingness to allocate sources for new attitudes
Problems with client relations	
	ineffective direction of client
	incorrect and unclear input from client
	clients' rashness to start construction
	ineffective feasibility studies from client
	ill planned project process
	unnecessary information interchange in meetings
	insufficient information sharing of stakeholders
	not use of written documents for decisions
	architects' lack of knowledge about the buildings' function and operation
	designers not caring the application problems/cost
	discrepancy of "value" concept for client and designers

3.3.7 Unused Employee Creativity

Owing to the deep relationship between design practice and highlighting the creativity of employees, the ideas of respondents about this waste category were extremely clear. All of them agreed that unused employee creativity is a common faced waste in architectural design process and then referred to its possible sources.

Respondent C mentioned the hardness to professionalize on a specific task. Respondents E and F joined respondent C by emphasizing the inability to provide employee creativity. Respondents E and H added the extremely limited time allowed for architectural design project production. Respondents D and F claimed that not expecting employees to make philosophical contribution and take responsibility is another reason for being unable to benefit efficiently from employees. Respondent G addressed the unqualified and missing organization chart. Respondent F joined respondent G by referring insufficient authority sharing (owner based system). Finally, respondents C, E and G all stated that the unawareness about the qualifications of personnel is a reason for unused employee creativity in architectural design process.

Table 3.8 Unused employee creativity waste item and sources

Unused employee creativity	
	not expecting employees to make philosophical contribution and take responsibility
	unawareness about the qualifications of personnel
	inability to provide employee continuity
	extremely limited time allowed for architectural design project production
	insufficient authority sharing (owner based system)
	unqualified and missing organization chart
	unwillingness to allocate sources for new attitudes
	hardness to professionalize on a specific task

3.3.8 Transportation

Since architectural design process aims to create value by producing service instead of industrial products, at first sight, it might be seen that there is no transportation waste occurred in the process. After analyzing the title from lean perspective, there are some situations came to the mind of respondents that the final product is being displaced without creating any value.

Respondent A, F and G addressed the final submission requirements of administrations and some of the clients. Since all drawing sheets need to have the signature of each and every discipline, there is a transportation waste occurred by carrying all the relevant sheets, documents, *etc*. Respondent F mentioned about the inefficiency of 250 - 300 signatures per project by each individual have the name on. Digitalized submission process is suggested by Respondent F at this point. Moreover, Respondent B attracted the attention to the unnecessary transportation works due to defective drawings, details *etc*.

Table 3.9 Transportation waste item and sources

Unnecessary transportation processes	
	inability to 100% digital submission of projects
	requirement of sheets with signs of all disciplines together

3.4 Frequency and Impact Evaluation Questionnaire

After the information about lean design waste items and their sources were obtained for each lean waste category, it was used as an input in the configuration of the questionnaire. All of the interviews were evaluated and a 28 item list for lean design wastes was reached with their sources.

The aim of the questionnaire is to reach architects actively working in the field and ask their opinion about;

- the frequency of occurrence and their
- impact over cost,
- impact over duration and
- impact over quality of the project for each waste item.

In this way it is targeted to provide waste item list with probability of occurrence and impact evaluation information for a further possible lean design management model study.

3.4.1 Execution and Participants

Questionnaire was preferred due to its effectiveness and practicality for surveying over respondents from a broad population. The questionnaire was created in online environment in order to reach the ideas of a wide population in relatively short time period with less physical effort. Moreover, online questionnaire increases the efficiency of evaluation process by providing data in digital environment.

The questionnaire aimed to survey the opinions of architects performing actively in the industry. By considering the greatness of the total population, it is considered necessary to limit with the architects that have an active membership and e-mail address in Chamber of Architects, Ankara Branch. In order to reach determined population, an application letter was prepared including the information about the research methodology, university, aim and objectives of the study, the researcher and the web URL of the questionnaire designed. It was requested from the Chamber of Architects - Ankara Branch to forward the web URL of questionnaire to all members that have a valid e-mail address. After an evaluation process, Chamber of Architects - Ankara Branch posted a mass e-mail containing the web URL of questionnaire and asking for participation from all active members.

The pilot study is execution started in 10.01.2015 and finished by 17.01.2015 with the involvement of 30 participants coming from a variety of backgrounds in the architectural profession. The objective was to determine whether there is a potential problem about the general layout of questionnaire and clarity of questions. Pilot study made the researcher able to capture some weak points and make improvements. The material of pilot study had a number of points that were hard to understand because a great percentage of respondents had no idea about the lean philosophy and its concept. Moreover, there were problems detected by the initial respondents regarding design, visual decisions and font sizes of the draft questionnaire. Eventually, specified problems were eliminated and final version of questionnaire is prepared.

The web URL of questionnaire was held open from 20.01.2015 to 04.02.2015 and

244 initial responds collected out of 1632 active members of Chamber in this time period. That corresponds to 14,95% initial response rate. However, only 151 of those questionnaires' compulsory areas were fully completed. So the evaluation is conducted with the involvement of 151 responds.

3.4.2 Structure of Questionnaire

The questionnaire starts with the information about the name and content of the study, the university, the content of the questionnaire and the number of questions in the questionnaire. The information also contains the development process of previous works and how the data they provided will be helpful for the following phases of study. The survey is conducted in Turkish language.

34 total questions of questionnaire were divided into two main question groups;
1. Information about professional identity (6 questions); and
2. Waste items frequency and impact evaluation (28 waste items).

The first question group named as "Information about professional identity", focused on personal information including; (1) number of years that the participant is working in project environment; (2) number of years that the organization of participant is working in project environment; (3) the job position that the participant is working; (4) the amount of projects that the organization of participant finished annually; (5) the total number of personnel working in the organization of participant; and (6) building types that the participants are involved in project process of. All of those questions were multiple-choice type. Only the sixth question was available for multiple answers while the others only available for one choice. The third and sixth questions both have the "other" choice which has to be typed if that is the decision.

The second question group - Waste items frequency and impact evaluation" - was consisted of a list of 28 lean design wastes with two explanatory illustrations under each of them. Each waste item is considered as a question and their: (1) probability of occurrence, (2) impact over project cost, (3) impact over project duration, and (4) impact over project quality are examined with multiple choice questions. So there are a total of 112 (28 x 4) questions to be answered in second group. Only second group of questions were defined as compulsory to answer, so every responds having that section fully filled were accepted as a completed questionnaire and included in evaluation process.

After reading the relevant explanations and illustrations, the respondents are expected to choose four range defining answers determined as "4-very high", "3-high", "2-low" and "1-zero" were the possible answers for each four parameter. A four point scale for the answer options was preferred instead of 3-5 point in order to prevent respondents opt out or give uncertain decisions by selection of the answer in the middle with no-decision (Fellows and Liu, 2008).

In this chapter, the research framework was introduced firstly and then being the initial part of the framework, the objective, structure and sample selection criteria of interview were mentioned. The results of interview were evaluated under 8 headings each for one lean waste category. 28 design waste items revealed under 8 waste categories were used as input for the next phase of study: questionnaire. Next, the information regarding aim, execution, sample selection and structure of questionnaire was presented. The output data and evaluation of questionnaire were discussed in Chapter 4.

CHAPTER 4

RESULTS AND DISCUSSION

The results of questionnaire are given and evaluated in this chapter. After the methodology of questionnaire was given, the evaluation is started with first part of questionnaire. The responses of participants regarding their professional background were given place firstly to get familiar with the population.

Then the responses given in second part of questionnaire were presented and analyzed. Firstly, the waste items were compared according to their frequency of occurrence and effect over project value parameters (impact over cost, impact over duration and impact over quality). Then the waste items compared according to their risk values (cost, duration and quality). Next, a comparison between the average values of three different project parameters is presented. After the answers of respondents from different professional backgrounds were analyzed, the chapter is concluded with the comparison of average values of 8 different waste categories over three different value parameters (cost, duration and quality).

To begin with, this questionnaire was developed to find out the perceptions of architects who are active members of Chamber of Architects (Turkey) - Ankara Branch about the a) frequency of occurrence, b) impact over project cost, c) impact over project duration, and d) impact over project quality of 28 pre-determined lean design waste items. Accordingly, the study focuses on the questions below:

1. What are CA - Ankara Branch member architects' perception towards the

a) frequency of occurrence;
b) impact over project cost;
c) impact over project duration, and;
d) impact over project quality of 28 lean design waste items?

2. Are there any remarkable difference between architects' perception according to;

a) their years of experience;
b) their organizations' years of experience;
c) their job position;
d) amount of work that their organization completed annually; and
e) total number of personnel that their organization have?

3. Are there any waste category becoming prominent for different parameters of a Project (*i.e.*, cost, duration, quality)?

This section of the study includes information on the quantitative analysis of the data collected via questionnaires. Following the completion of data collection, the outputs were transferred to SPSS 20. Answer choices in Likert scale of second section questions were weighted as: 1-*zero*, 2-*low*, 3-*high*, 4-*very high*.

Both survey tool and SPSS were employed for data analysis and presentation. Survey tool is preferred for creating graphics, tables and basic numeric expressions such as frequencies, mean value, percentage and standard deviations *etc*. On the other hand, SPSS was employed for further quantitative statistical tests.

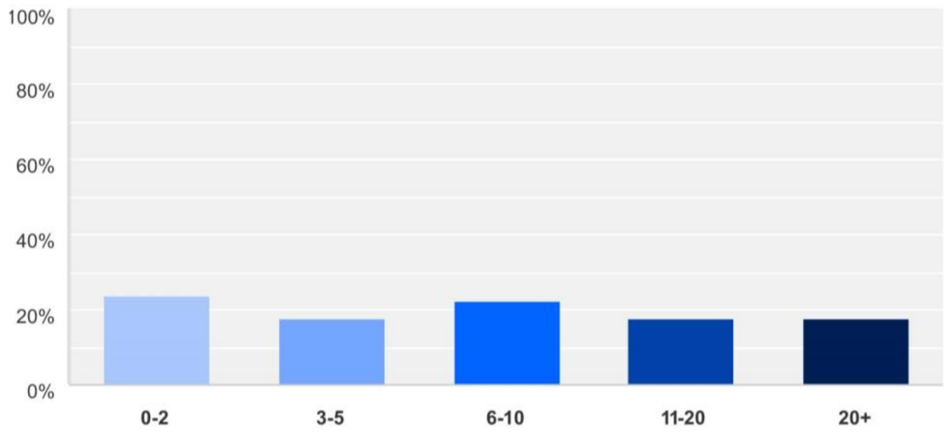
Firstly, the statistical information of sample selection is provided. The information presented in section 4.1 was obtained from frequencies, means, and percentages of the answers in first section, which are presented in detail. Then various arrangements of answers regarding waste items are given. In this section, the waste items are rated according to mean value of their frequency of occurrence, impact over cost, impact over duration and impact over quality. A variety of further analyzes related to *risk values* of waste items are also provided. Then, the results of one-way ANOVA tests are presented for determining if there is a remarkable difference between the evaluations of various sample groups according to their answers in the first section. And finally, the results of one way within subjects ANOVA tests are given to determine whether there are any differences between population means of parameters regarding different waste category average scores.

4.1 Professional Information of Sample Population

In this section, the answers of respondents regarding experiences of their own and their organizations are presented. The graphics remarking the responses for each six question is given and then brief explanation and evaluation is given place for the answers.

The questions placed in this first section of the questionnaire were not compulsory. The questionnaires where 28 questions in the second section were answered fully were accepted as completed questionnaires and evaluated accordingly. Hence total response number of the questions in this section can be less than 151. The responses specified under "other" choice may also not be presented in that number of answer. The graphics exported from survey tool and further processed by the researcher.

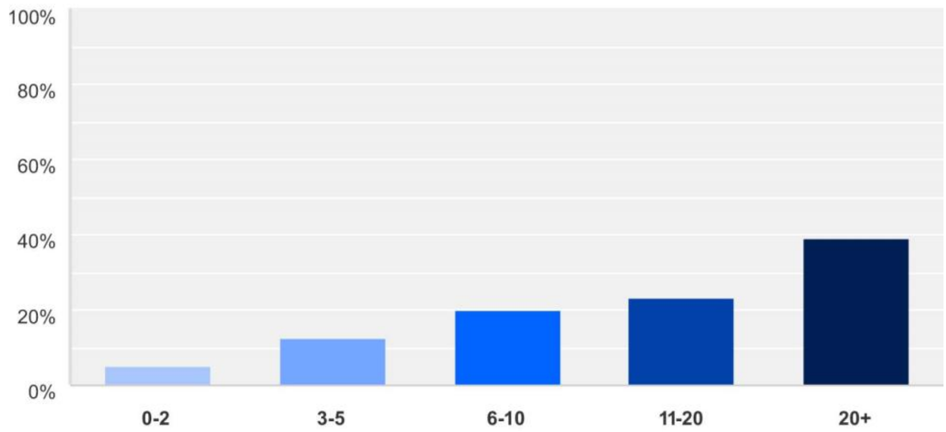
Table 4.1 Number of years that participants are working in project environment



Answer Choices	Responses	
0-2	23.84%	36
3-5	17.88%	27
6-10	22.52%	34
11-20	17.88%	27
20+	17.88%	27
Total		151

By analyzing the answers given to the first question, it can be deduced from the table that the distribution according to experiences of participants is balanced. Such a distribution without a remarkable accumulation on a specific interval is commented positively by considering its ability to represent the opinions of the whole industry. It has also been seen constructive for enabling the research for further analysis and comparisons accordingly.

Table 4.2 Number of years that the organizations of participants is performing in project environment

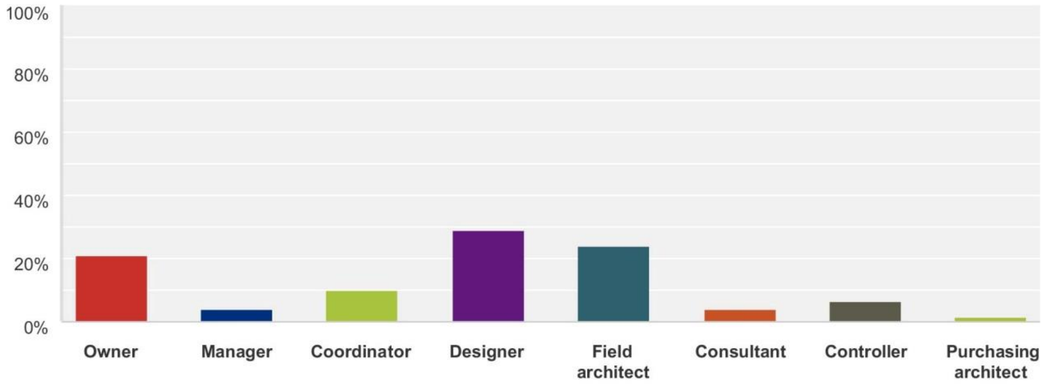


Answer Choices	Responses	
0-2	**5.30%**	8
3-5	**12.58%**	19
6-10	**19.87%**	30
11-20	**23.18%**	35
20+	**39.07%**	59
Total		**151**

Table 4.2 shows number of years that the organizations of participants performing in the project environment. High ratio of organizations having more than 20 years' experience was considered satisfactory by assuming that professionals in such organizations can realize the inefficiencies of the industry more easily. This is due to

the expectation that the organizations performing for longer periods of time has more institutional awareness that they can reflect to their employees. In this context, the findings are also remarkable that about 62% of the respondents are working in organizations having more than 10 years' experience and only about 17% of the respondents are working in organizations having less than 5 years' experience.

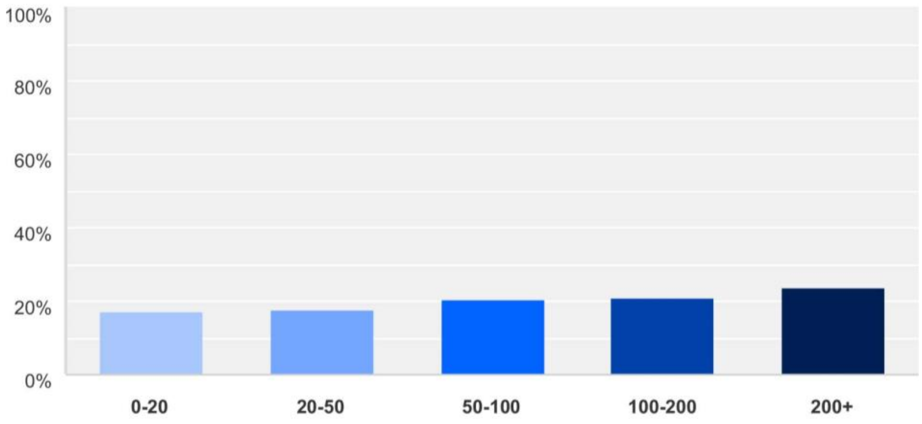
Table 4.3 Job position that the respondents are working



Answer Choices	Responses	
Owner	21.13%	30
Manager	4.23%	6
Coordinator	9.86%	14
Designer	28.87%	41
Field architect	23.94%	34
Consultant	4.23%	6
Controller	6.34%	9
Purchasing architect	1.41%	2
Total		**142**

The answers given to question 3 are illustrated with the table above. It is seen that although a variety of respondents is a matter; the owners, designers and field architects constitutes about 74% of the sample responded to the question. Considering that most owners performing in design industry have their own design office, they can also be addressed as designers at the same time. This diversification was also found constructive for analyzing the perspectives of actors from different areas of the industry.

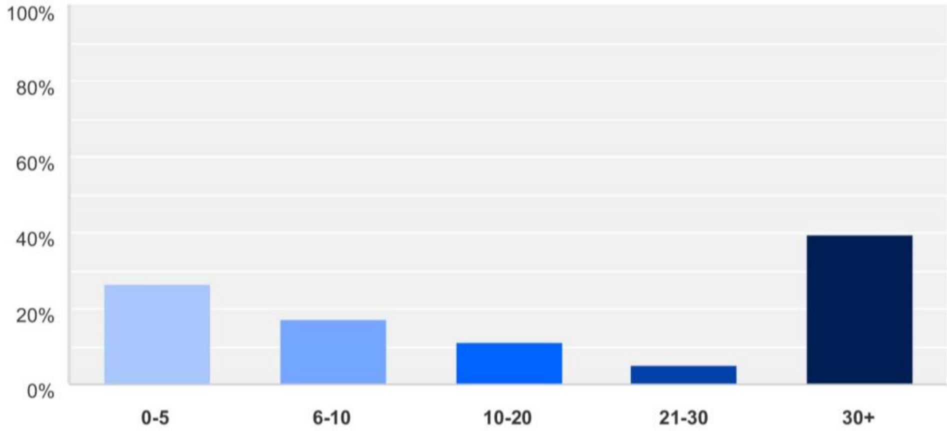
Table 4.4 The amount of projects that the organization of respondents finished annually (thousands m^2)



Answer Choices	Responses	
0-20	17.01%	25
20-50	17.69%	26
50-100	20.41%	30
100-200	21.09%	31
200+	23.81%	35
Total		147

Being similar to answers of first question, there is a balanced distribution observed. This dispersion is seen favorable for making the research available for further analyzes by comparing the answers of respondents coming from organizations having unequal amount of projects handled annually. On the other hand, in terms of being able to realize the wastes in the industry, it is affirmative that about 83% of the respondents are working in organizations completing at least 20000 m^2 design work in a year.

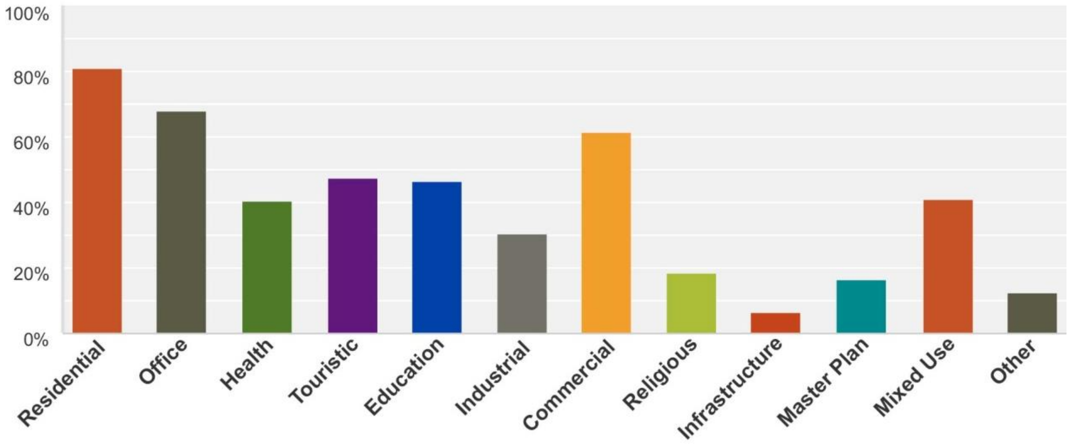
Table 4.5 Total number of personnel working in the organization of respondents



Answer Choices	Responses	
0-5	**26.67%**	40
6-10	**17.33%**	26
11-20	**11.33%**	17
21-30	**5.33%**	8
30+	**39.33%**	59
Total		**150**

The high percentage of organizations having 0-5 personnel and 30+ personnel is found remarkable at this point. The diversity of perspectives of respondents who are working on organizations at two different edges of this chart is seen possible to be analyzed and compared to capture whether there is a significant difference or not.

Table 4.6 Types of projects that the respondents are involved in project processes



Answer Choices	Responses	
Residential	80.79%	122
Office	68.21%	103
Health	40.40%	61
Touristic	47.68%	72
Education	46.36%	70
Industrial	30.46%	46
Commercial	61.59%	93
Religious	18.54%	28
Infrastructure	6.62%	10
Master Plan	16.56%	25
Mixed use	41.06%	62
Other	12.58%	19
Total Respondents: 151		

This is the final question and the only one that is available for multiple answers. The table can be investigated to have an idea of respondents' portfolios. The answers indicated next to "other" choice can be classified as: transportation (6), public buildings (3), sports (4), urban development (2), restoration (2), cultural (3).

4.2 Waste Item Ratings

Following the introduction of questionnaire sample population, the study continues with focusing and analyzing the evaluations of architects for 28 defined waste items. As stated before, the participants were asked to evaluate four parameters for each waste item. The parameters aim to measure the probability of occurrence and their impact over cost, impact over duration, and impact over quality when they occur. All answer choices in the second section were a four point Likert scale defined as 1-*zero*, 2-*low*, 3-*high*, 4-*very high*. In this way, it is anticipated to determine prior bottlenecks against increasing the efficiency of architectural design processes.

This section contains the analysis and illustrations of mean scores and standard deviations belonging to 28 waste items and their parameters. For each waste item, mean scores and standard deviations were quantitatively calculated for the frequency of occurrence, impact over cost, impact over duration and impact over quality values. The answers from all the respondents were evaluated together without any discrimination in this part.

4.2.1 Comparison of Waste Items According to Parameters

Firstly, the ranking of waste items according to mean scores of their frequency of occurrence values is illustrated below in Figure 4.1. The data reveals that *"revision works according to data provided from other disciplines"* $\overline{x}$[1]= 2,92 (SD[2] = 0,78) is the most frequently encountered waste out of 28 items. This is an item from "*defects/correction*" waste category. In reference to the evaluations of interviewees, the waste can be resulting from (1) impossibility of co-operation between all disciplines from the commencement of the project, (2) stakeholders' lack of core knowledge about different disciplines, (3) jumping to the next phase before necessary information reached from other disciplines, (4) clients' special desire to work with a previously determined engineering team, (5) not following the

---

[1] $\overline{x}$ = mean value
[2] SD = standard deviation

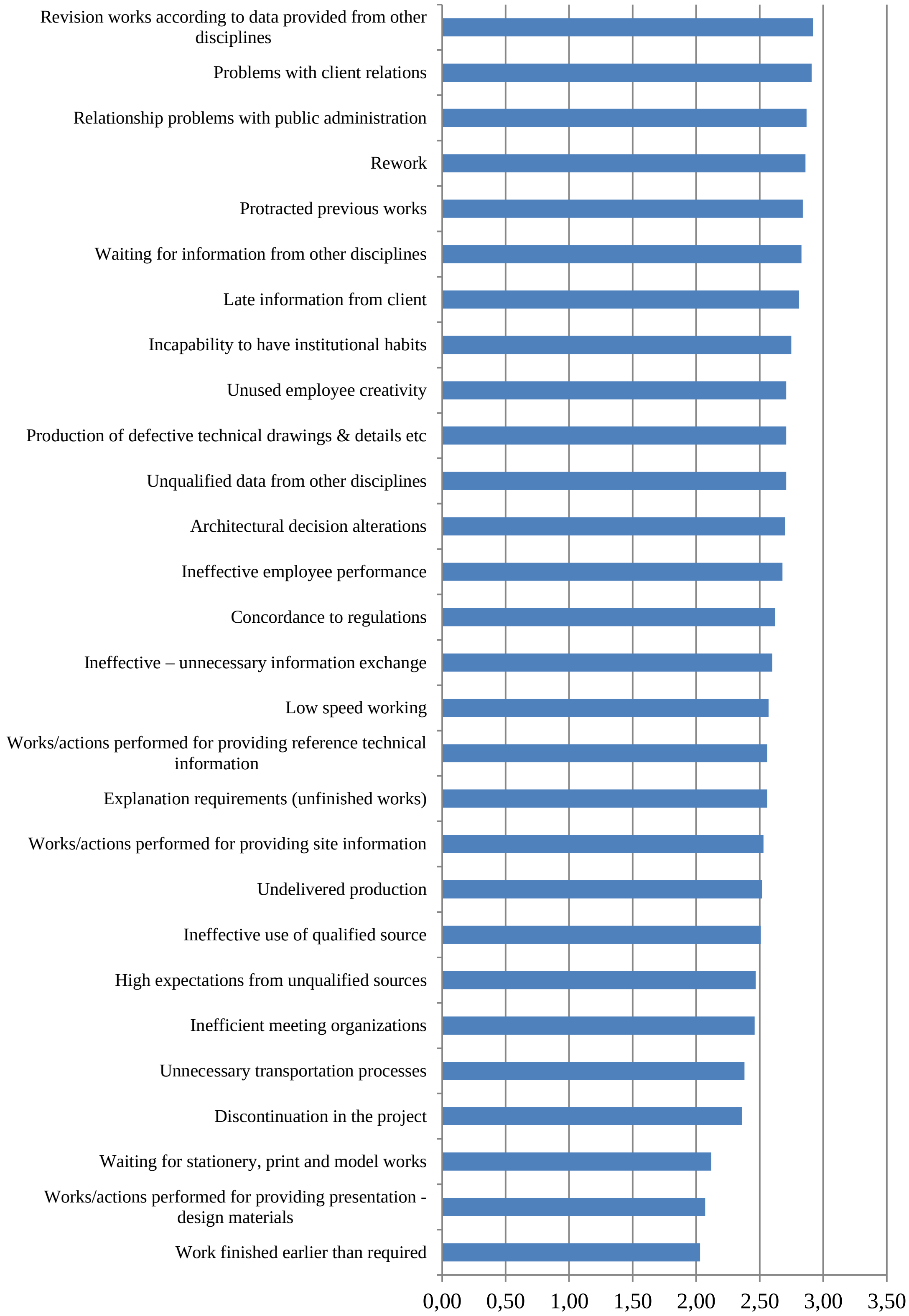


Figure 4.1 Waste item rankings according to their *frequency of occurrence* scores

innovations in the industry, and (6) lack of self-evaluation of the organization. So the interview and questionnaire together reaches the point that the waste item occurred as a result of the factors above is the most frequently experienced one among 28 determined. It is also remarkable that 4 of first 7 wastes in the table belongs to "*waiting*" category: "*relationship problems with public administrations*" $\overline{x}$ = 2,87 (SD = 0,75), "*protracted previous works*" $\overline{x}$ = 2,84 (SD = 0,70), "*waiting for information from other disciplines*" $\overline{x}$ = 2,83 (SD = 0,61) and "*late information from client*" $\overline{x}$ = 2,81 (SD = 0,70). It can be captured from the figure that "*Problems with client relations"* $\overline{x}$ = 2,91 (SD = 0,75) and "*rework*" $\overline{x}$ = 2,86 (SD = 0,76) were the other waste items at the top of the list. On the other hand, "*works finished earlier than required*" $\overline{x}$ = 2,03 (SD = 0,75), has been seen as the least occurred waste among all listed items. "*Works/actions performed for providing presentation - design materials*" $\overline{x}$ = 2,07 (SD = 0,65), "*waiting for stationery, print and model works*" $\overline{x}$ = 2,12 (SD = 0,64), "*discontinuation of the project*" $\overline{x}$ = 2,36 (SD = 0,70), and "*unnecessary transportation processes"* $\overline{x}$ = 2,38 (SD = 0,83), were evaluated as rarely existed waste items by the architects.

After frequency of occurrence, the ranking of items with respect to mean score for "impact over cost" values is presented. As seen in Figure 4.2, the rankings have changed when the probability of occurrence mean values are evaluated. This time all the 7 items at the top of the list are from only two waste categories: *overprocessing* and *defects/correction.* "*rework*" $\overline{x}$ = 2,91 (SD = 0,78), "*ineffective employee performance*" $\overline{x}$ = 2,80 (SD = 0,81), "*problems with client relations*" $\overline{x}$ = 2,78 (SD = 0,78) and "*unqualified data from other disciplines*" $\overline{x}$ = 2,73 (SD = 0,72) are the items of *overprocessing* category. And "*architectural decision alterations*" $\overline{x}$ = 2,80 (SD = 0,75), "*revision works according to data provided from other disciplines*" $\overline{x}$ = 2,79 (SD = 0,75) and "*production of defective technical drawings and details etc.*" $\overline{x}$ = 2,75 (SD = 0,73) are the items from *defects/correction* category. Conversely, "*waiting for stationery, print and model works*" $\overline{x}$ = 2,03 (SD = 0,72) has been evaluated as the item has least effect over the project cost. Interestingly, 4 of 7 items at the bottom of the list belong to *motion* waste category: "*works / actions performed*

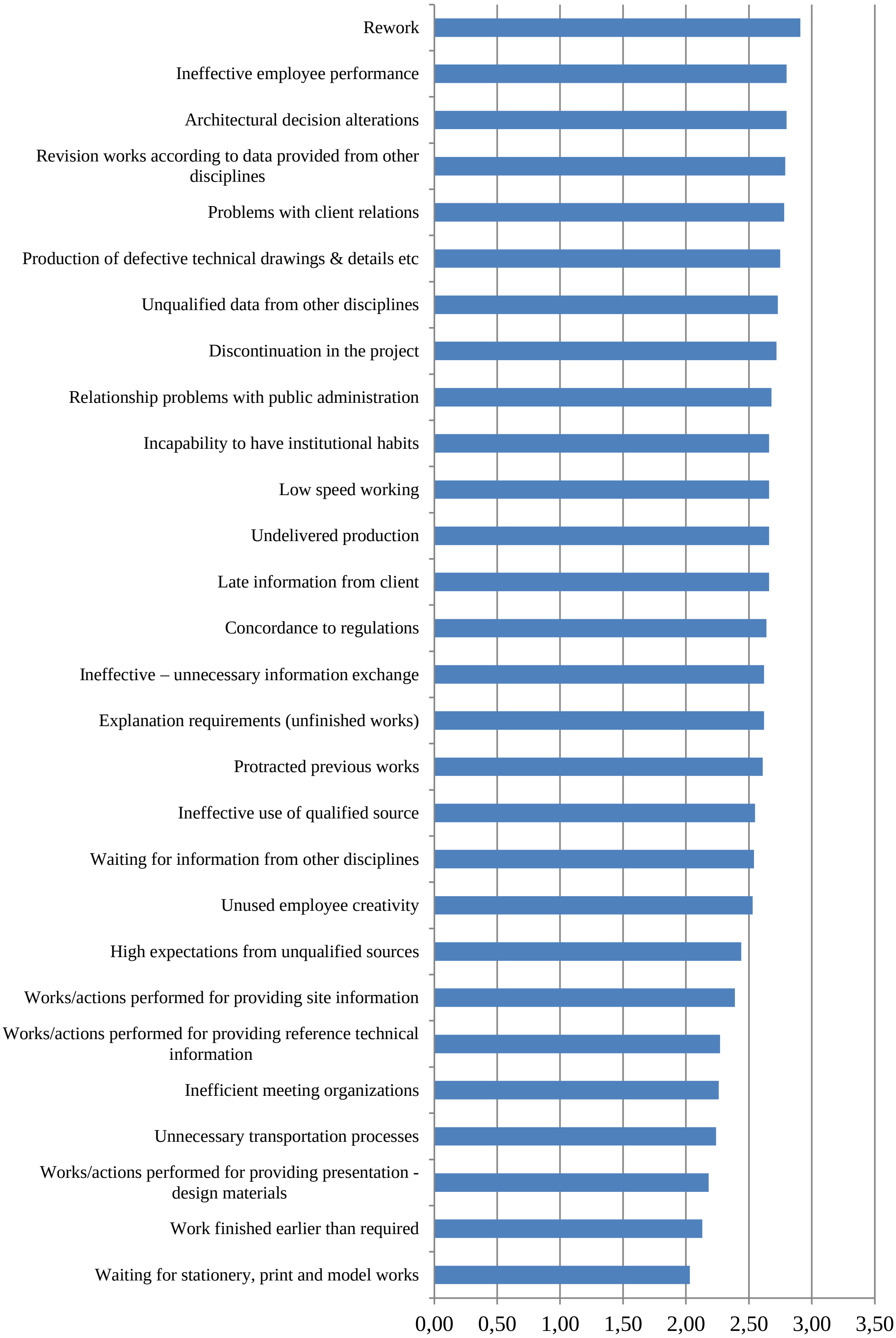


Figure 4.2 Waste item rankings according to their *impact over project cost* scores

for providing presentation - design materials" $\overline{x}$ = 2,18 (SD = 0,73), "*inefficient meeting organizations*" $\overline{x}$ = 2,26 (SD = 0,78), "*works/actions performed for providing reference technical information*" $\overline{x}$ = 2,27 (SD = 0,80), and "*works/actions performed for providing site information*" $\overline{x}$ = 2,39 (SD = 0,83). And by considering all the wastes of motion category are listed in last 7 row, it can be said that the respondents are not considering motion category is effective in increasing the cost of the project. Other items seen as having least negative impact over cost of project are "*works finished earlier than required*" $\overline{x}$ = 2,13 (SD = 0,82) and "*unnecessary transportation processes*" $\overline{x}$ = 2,24 (SD = 0,84).

In the next step, the items ranked according to their mean value for "impact over duration" scores accordingly. According to Figure 4.3 "*rework*" $\overline{x}$ = 3,20 (SD = 0,73) is the waste item that has the greatest impact over the project duration as like previous parameter -impact over project cost. 5 of first 6 waste items on top of the list are belonging to "waiting" category. The wastes in question are: "*discontinuation in the project*" $\overline{x}$ = 3,18 (SD = 0,85), "*late information from client*" $\overline{x}$ = 3,18 (SD = 0,70), "*relationship problems with public administration*" $\overline{x}$ = 3,11 (SD = 0,76), "*protracted previous works*" $\overline{x}$ = 3,11 (SD = 0,69) and "*waiting for information from other disciplines*" $\overline{x}$ = 3,08 (SD = 0,70). Conversely, the only left waste item of *waiting* category is placed at the bottom of the table surprisingly: "*waiting for stationary, print and model works*" $\overline{x}$ = 2,16 (SD = 0,76). The other waste items whose effects are considered minimum by the respondents are "*works / actions performed for providing presentation - design material*" $\overline{x}$ = 2,21 (SD = 0,76), "*work finished earlier than required*" $\overline{x}$ = 2,34 (SD = 0,90), "*unnecessary transportation processes*" $\overline{x}$ = 2,36 (SD = 0,86) and "*works / actions performed for providing reference technical information*" $\overline{x}$ = 2,49 (SD = 0,81).

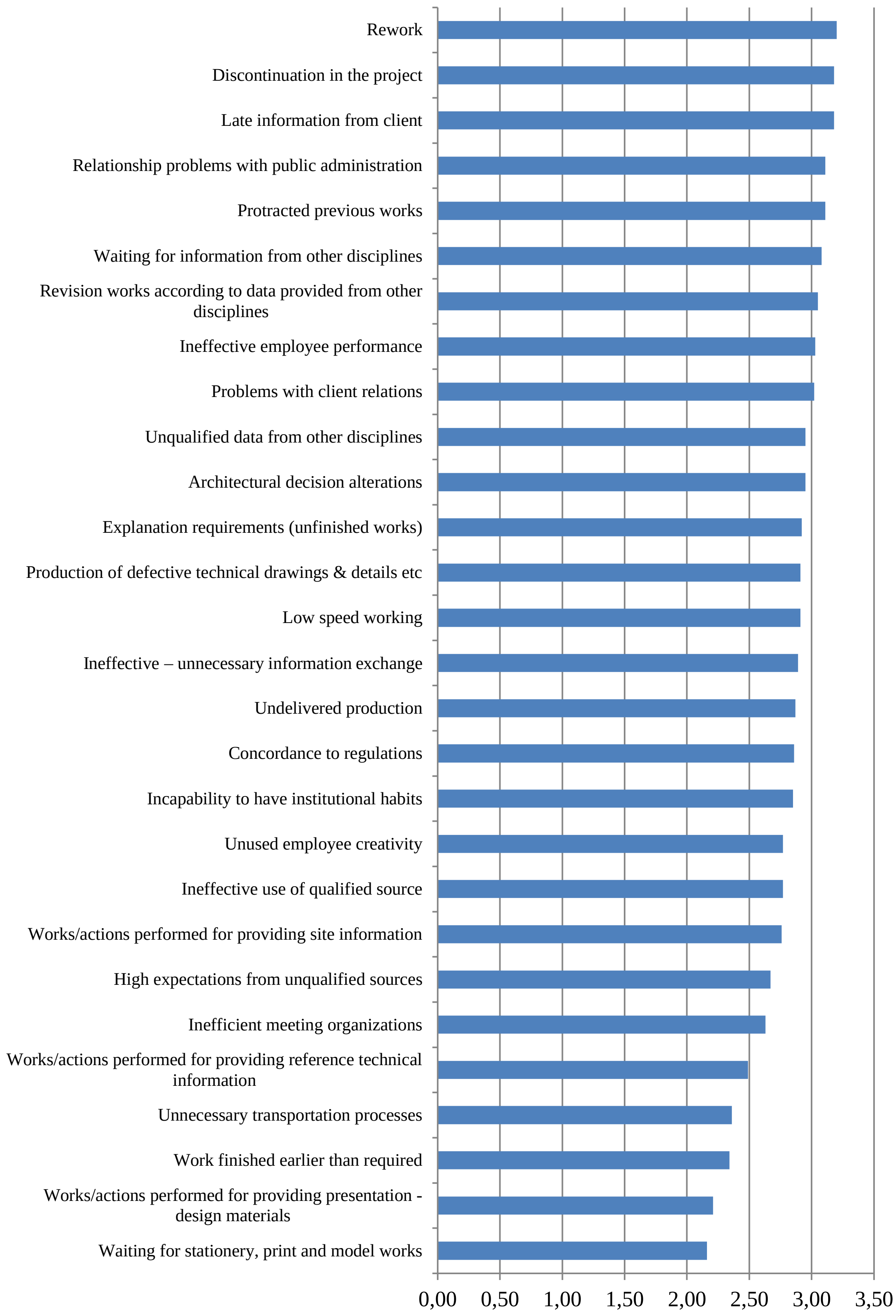


Figure 4.3 Waste item rankings according to their *impact over project duration* scores

Then, the rankings illustration was prepared with respect to waste items' mean value of "impact over quality" scores (Figure 4.4). The figure shows that two categories: *overprocessing* and *defects/correction* dominated 11 of first 12 rows according to the architects' answers. The mentioned waste items included in *overprocessing* category are: "*problems with client relations*" $\overline{x}$ = 3,02 (SD = 0,78), "*ineffective employee performance*" $\overline{x}$ = 2,93 (SD = 0,82), "*rework*" $\overline{x}$ = 2,91 (SD = 0,80, "*unqualified data from other disciplines*" $\overline{x}$ = 2,87 (SD = 0,75), "*incapability to have institutional habits*" $\overline{x}$ = 2,80 (SD = 0,87) and "*ineffective-unnecessary information exchange*" $\overline{x}$ = 2,75 (SD = 0,88). And "*production of defective technical drawings and details*" $\overline{x}$ = 2,92 (SD = 0,83), "*revision works according to data provided from othder disciplines*" $\overline{x}$ = 2,91 (SD = 0,80), "*architectural decision alterations*" $\overline{x}$ = 2,90 (SD = 0,85), "*explanation requirements (unfinished works)*" $\overline{x}$ = 2,83 (SD = 0,83) and "*concordance to regulations*" $\overline{x}$ = 2,81 (SD = 0,87) are the items in the body of *defects/correction* category. Another significant result derived from the figure is that *unused employee creativity* category is placed in 2. rank with its unique waste item with the same name $\overline{x}$ = 2,95 (SD = 0,80). So unused employee creativity is noticed by the designers as a major resource for unqualified architectural projects. Being similar with the "impact over cost" rankings, all 4 waste items of *motion* category are placed within last 7 rows by the respondents. To remember: "*works/actions performed for providing presentation - design materials*" $\overline{x}$ = 2,12 (SD = 0,78), "*works/actions performed for providing site information*" $\overline{x}$ = 2,38 (SD = 0,80), "*inefficient meeting organizations"* $\overline{x}$ = 2,46 (SD = 0,86) and "*works/actions performed for providing reference technical information*" $\overline{x}$ = 2,59 (SD = 0,85). The other items that had not been evaluated as significantly effective for decreasing the quality of design projects are: "*waiting for stationery, print and model works*" $\overline{x}$ = 1,89 (SD = 0,71), "*unnecessary transportation processes*" $\overline{x}$ = 1,96 (SD = 0,81) and "*work finished earlier than required*" $\overline{x}$ = 2,23 (SD = 0,86).

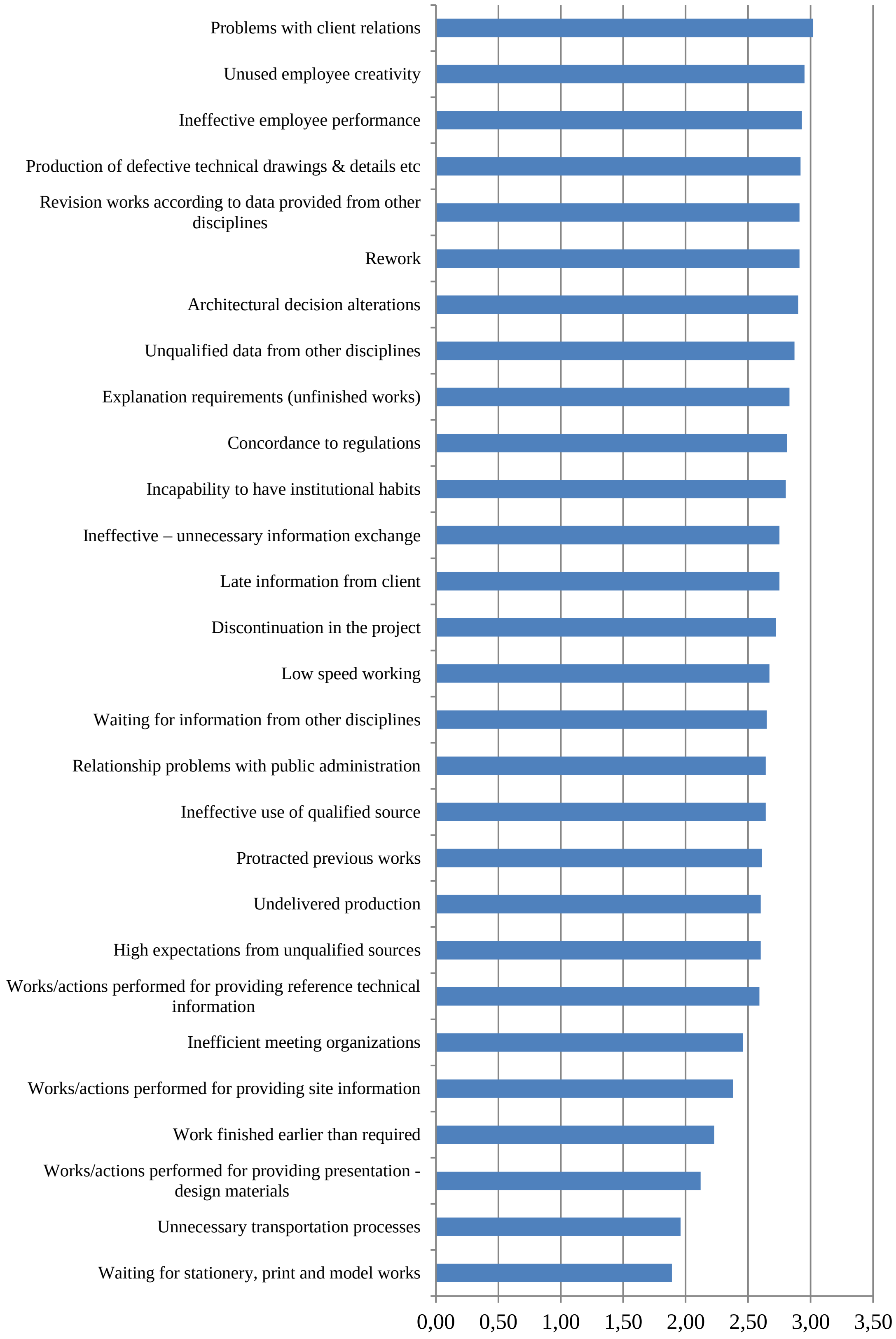


Figure 4.4 Waste item rankings according to their *impact over project quality* scores

4.2.2 Comparison of Waste Items According to Risk Values

So far, the evaluation is processed through four main parameters independently. The impact values are not considered when the assessment is made for frequency of occurrence. Similarly, impact values are scored and analyzed independent from the probability of occurrence.

In this context, after the presentation and evaluation with the mean scores of 4 parameters' separately, it is considered necessary to make an overall evaluation by incorporating both frequency of occurrence and impact values. At this point, risk concept is referred for framing the combination of such values meaningfully.

Risk is addressed as an uncertain outcome by Cretu et al. (2011) that means risk can both be understood as a threat or opportunity and it may both have negative and positive effects.

According to Hillson and Hulett, (2004) the risk concept is consisted up of two dimensions that can be described as uncertainty (specified as probability of occurrence) and the effect (specified as impact). The authors stated that the risk can be properly assessed by proper assessment of probability and impact of the event. Dumbravă and Iacob (2013) given place to the mathematical equation as "$R = I \times P$". Where "R" is standing risk value, "I" is for impact size and "P" is for probability.

By considering the possible outcomes and the uncertainty of the waste items referred in this study, a considerable relationship can be established between them and risk concept. In short, an evaluation is seen possible to be made with the involvement of both frequency of occurrence and impact values of the waste items. At this point, it is not aimed to obtain absolute numbers about their probability or impact percentages, but the objective is to reach a rating among waste items over their risk value. By this way, it is intended to guide the industry for creating a meaningful roadmap for reaching a lean design process. It is aimed to assist the professionals for deciding which steps to take on top priority and which ones can be solved in mid and long terms.

In this direction, this section contains evaluations and illustrations that use both the probability and impact values for reaching an overall *risk value* for each waste item.

To begin with, the 28 waste items were placed with respect to their frequency of occurrence and impact over cost mean values within the figure below (Figure 4.5). It can be captured from the figure that, waste items' frequency of occurrence and impact over cost values are correlated in general. "*Discontinuation of project*" (freq[3] = 2,36, i_c[4]=2,72) can be stated as an exception in the table. The respondents think that the impact of such a discontinuation over project cost will be remarkably high when compared to their perspective regarding its possibility of occurrence.

Then waste items ranked according to their "*cost risk value*" which is determined by the multiplication of *probability of occurrence* and *impact over cost* values as referred before. The results can be seen in Figure 4.6. Being different from independent results for the two parameters in question, there is no distinct clustering of a category in top and bottom of the list. There are wastes from 3 waste categories in top 5: "*rework*" (freq = 2,86, i_c = 2,91) and "*problems with client relations*" (freq = 2,91, i_c = 2,78) from *overprocessing*, "*revision works according to data provided from other disciplines*" (freq = 2,92, i_c = 2,79) and "*architectural decision alterations*" (freq = 2,70, i_c = 2,80) from *defects/correction* and "*relationship problems with public administration*" (freq = 2,87, i_c = 2,68) from *waiting* category. On the other hand, wastes from 4 different categories are placed on the bottom of the list. The waste items that have lowest risk value ratings are "*waiting for stationery, print and model works*" (freq = 2,12, i_c = 2,03) from *waiting* category, "*Work finished earlier than required*" (freq = 2,03, i_c = 2,13) from *inventory* category, "*works/actions performed for providing presentation - design materials*" (freq = 2,07, i_c = 2,18) and "*inefficient meeting organizations*" (freq = 2,46, i_c = 2,26) from *motion* category and "*unnecessary transportation processes*" (freq = 2,38, i_c = 2,24) from *transportation* category. It should be noted that the waste items in first and last three rows have remarkably distinctive values compared to others.

---

[3] freq = frequency of occurrence mean value
[4] i_c = impact over cost mean value

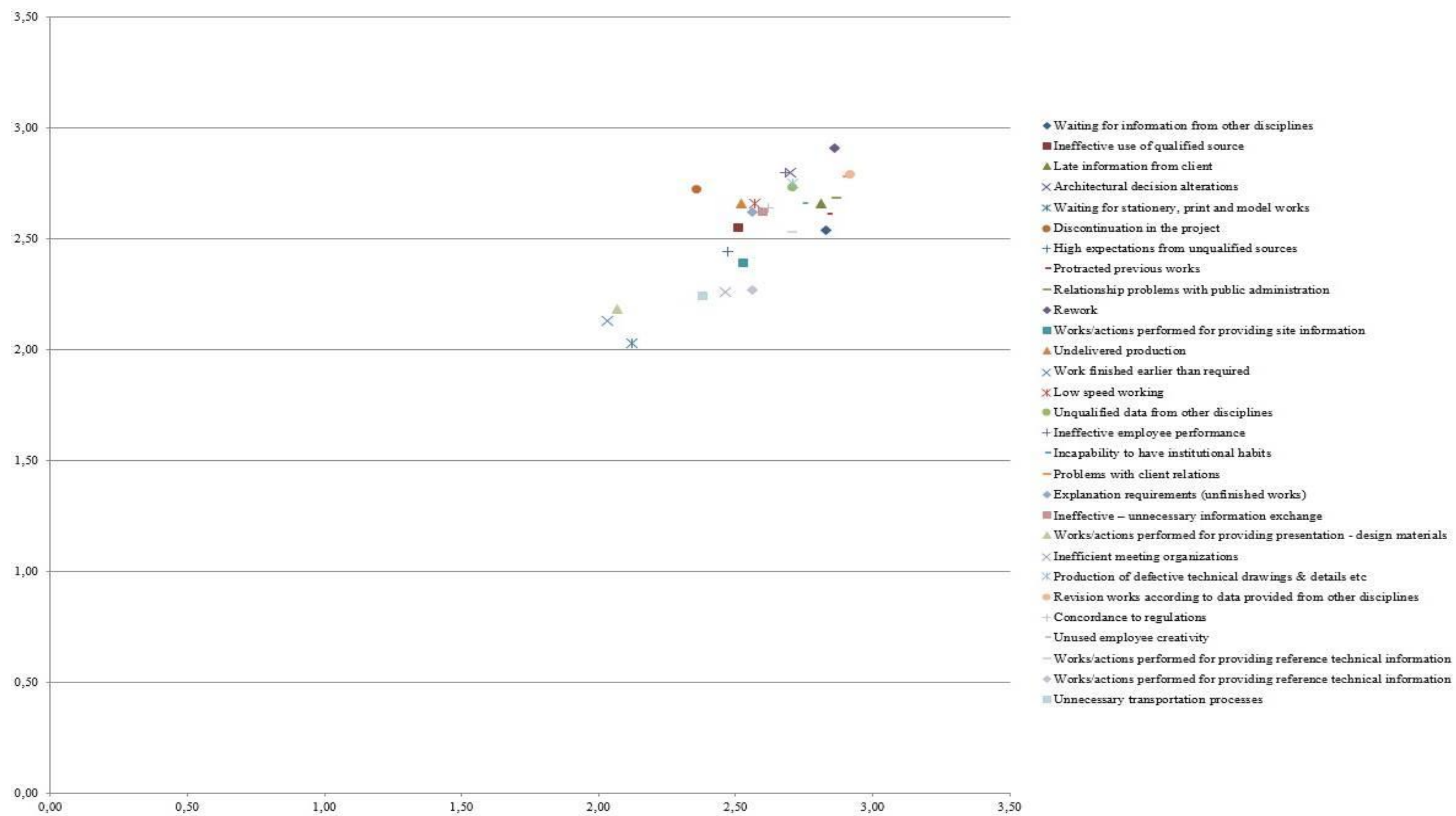


Figure 4.5 Distribution of waste items with respect to their *frequency of occurrence* and *impact over cost* mean values

Figure 4.6 Waste item rankings according to their *cost risk value* scores

After impact over cost parameter, a similar process is followed with the involvement of impact over duration. All waste items were positioned according to their frequency of occurrence and impact over duration mean values as seen in Figure 4.7.

According to figure, the situation is similar when compared to correlation of previous parameters. Waste items' frequency of occurrence and impact over duration values are paralleled in general. However, "*discontinuation of project*" (freq = 2,36, i_d[5] = 3,18) acted unlikely. According to respondents, aforementioned waste item is not one of the highest possible ones to occur, on the other hand, it is thought that its impact will be more than most of the rest.

Later on waste items ranked according to their "*duration risk value*" which is determined by the multiplication of *probability of occurrence* and *impact over duration* values similarly. The results are illustrated in Figure 4.8. In a similar direction with the *impact over project duration* rankings as in Figure 4.3, *waiting* category is prominent with 3 waste items out of first 5. "*Late information from client*" (freq = 2,81, i_d = 3,18), "r*elationship problems with public administration*" (freq = 2,87, i_d = 3,11), and "*protracted previous works*" (freq = 2,84, i_d = 3,11) are the items from *waiting* category. The other two outstanding items are "*rework*" (freq = 2,86, i_d = 3,20) from *overprocessing* category and "*revision works according to data provided from other disciplines*" (freq = 2,92, i_d = 3,05) from *defects/correction* category. Being similar to data of cost risk value rankings in Figure 4.6, there are waste items from 4 different categories in last 5 row of ranking according to duration risk value. "*Works/actions performed for providing presentation - design materials*" (freq = 2,07, i_d = 2,21) and "*Works/actions performed for providing reference technical information*" (freq = 2,56, i_d = 2,49) from *motion* category, "*waiting for stationery, print and model works*" (freq = 2,12, i_d = 2.16) from *waiting* category, "*Work finished earlier than required*" (freq = 2,03, i_d = 2,34) from *inventory* category and "*unnecessary transportation processes*" (freq = 2,38, i_d = 2,36) from *transportation* category.

---

[5] i_d = impact over duration mean value

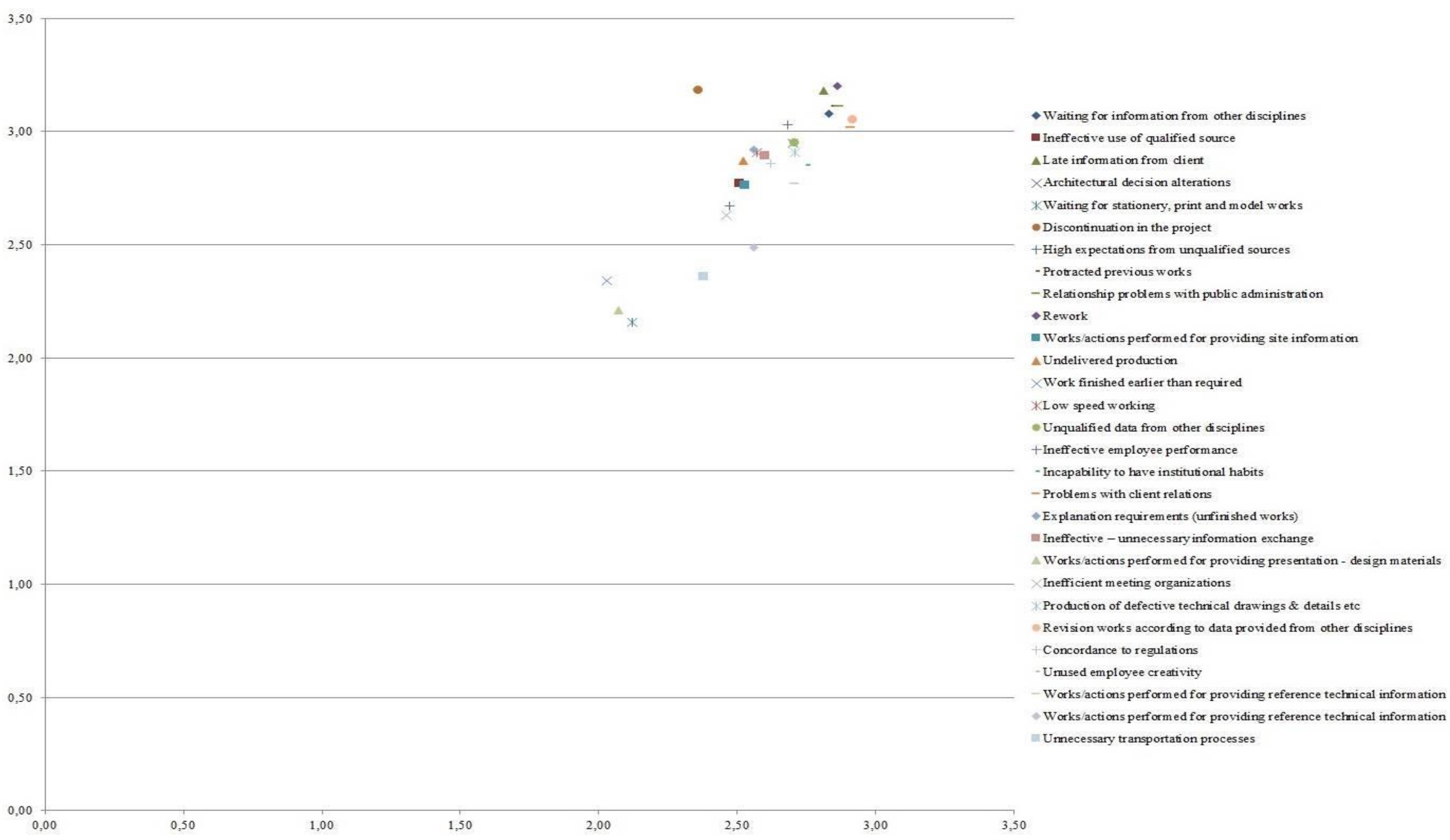


Figure 4.7 Distribution of waste items with respect to their *frequency of occurrence* and *impact over duration* mean values

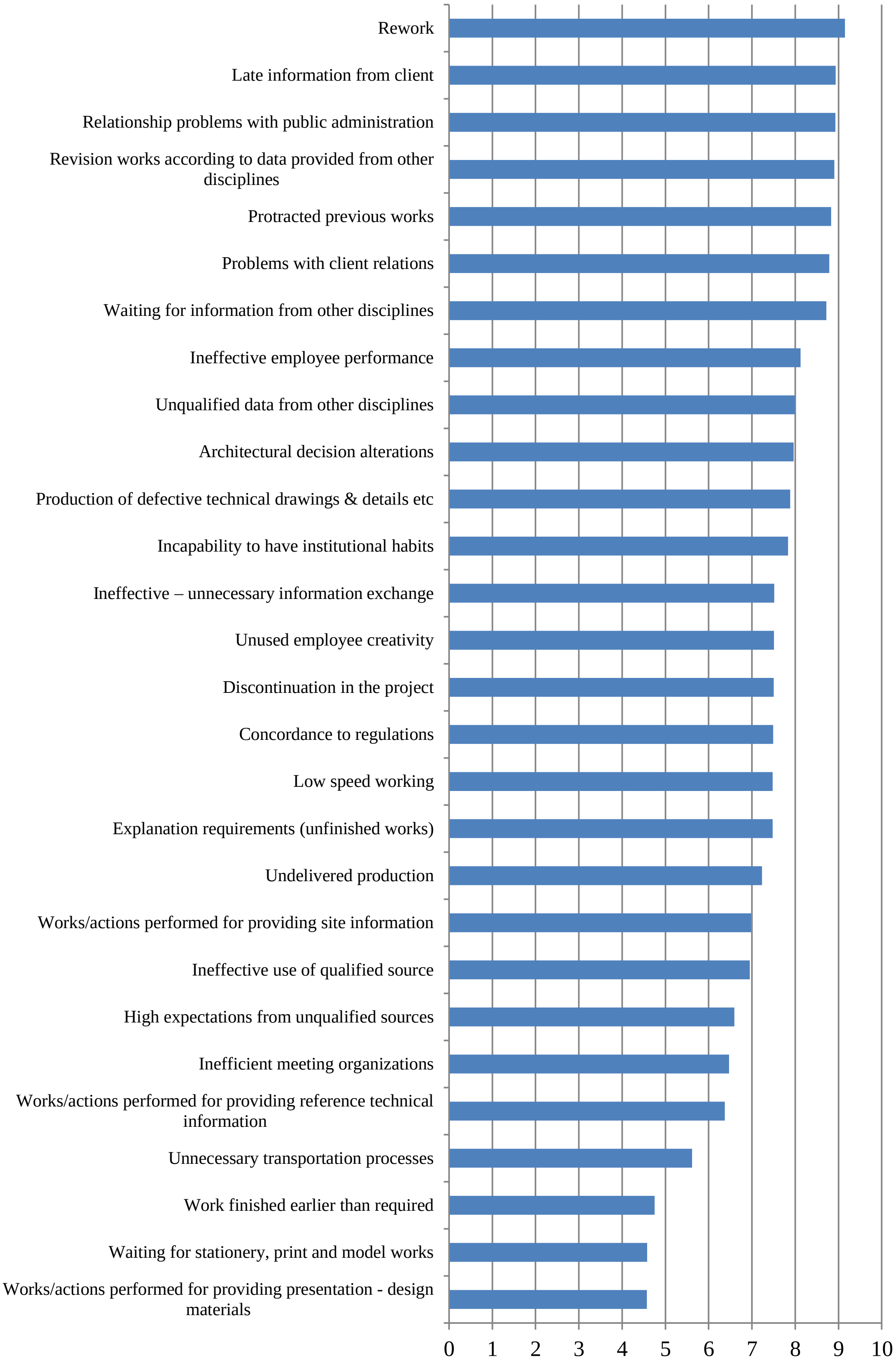


Figure 4.8 Waste item rankings according to their *duration risk value* scores

Finally, the same operations were employed with the mean scores of frequency of occurrence and impact over quality values. Figure 4.9 shows the placement of 28 waste items accordingly. The figure remarks that the mean values of frequency of ocurrance and impact over quality scores are correlated in general. By this manner the data is similar with the output of two previous probability and impact distribution graphics. Unlikely, the score given for frequency of occurrence of "*unnecessary transportation processes*" (freq = 2,38, i_q[6] = 1,96) is relatively high when compared to its score for impact over quality. And the opposite view is valid for "*discontinuation of project*" (freq = 2,36, i_q = 2,72) and "*work finished earlier than required*" (freq = 2,03 , i_q = 2,23).

Similarly, waste items ranked according to their "*duration risk value*" which is determined by the multiplication of *probability of occurrence* and *impact over quality* values. Figure 4.10 shows that there is no dominance of a specific waste category in the first 5 waste items. There are two waste items: "*problems with client relations*" (freq = 2,91, i_q = 3,02) and "*rework*" (freq = 2,86, i_q = 2,91) from *overprocessing* category, two items: "*revision works according to data provided from other disciplines*" (freq = 2,92, i_q = 2,91) and "*production of defective technical drawings and details etc.*" (freq = 2,71, i_q = 2,92) from *defects/correction* category, and "*unused employee creativity*" (freq = 2,71, i_q = 2,95) as the single item of the category with the same name. Similarly, there are wastes from 4 different category in 5 waste items having minimum scores of *quality risk value*. Namely: "*waiting for stationery, print and model works*" (freq = 2,12, i_q = 1,89) from *waiting* category, items according to their duration risk value have items from 4 different category; "*works/actions performed for providing presentation - design materials*" (freq = 2,07, i_q = 2,12) and "w*orks/actions performed for providing site information*" (freq = 2,53, i_q = 2,38) from *motion* category; "*work finished earlier than required*" (freq = 2,03, i_q = 2,23) from *inventory* category and "*unnecessary transportation processes*" (freq = 2,38, i_q = 1,96) from *transportation* category.

[6] i_q = impact over quality mean value

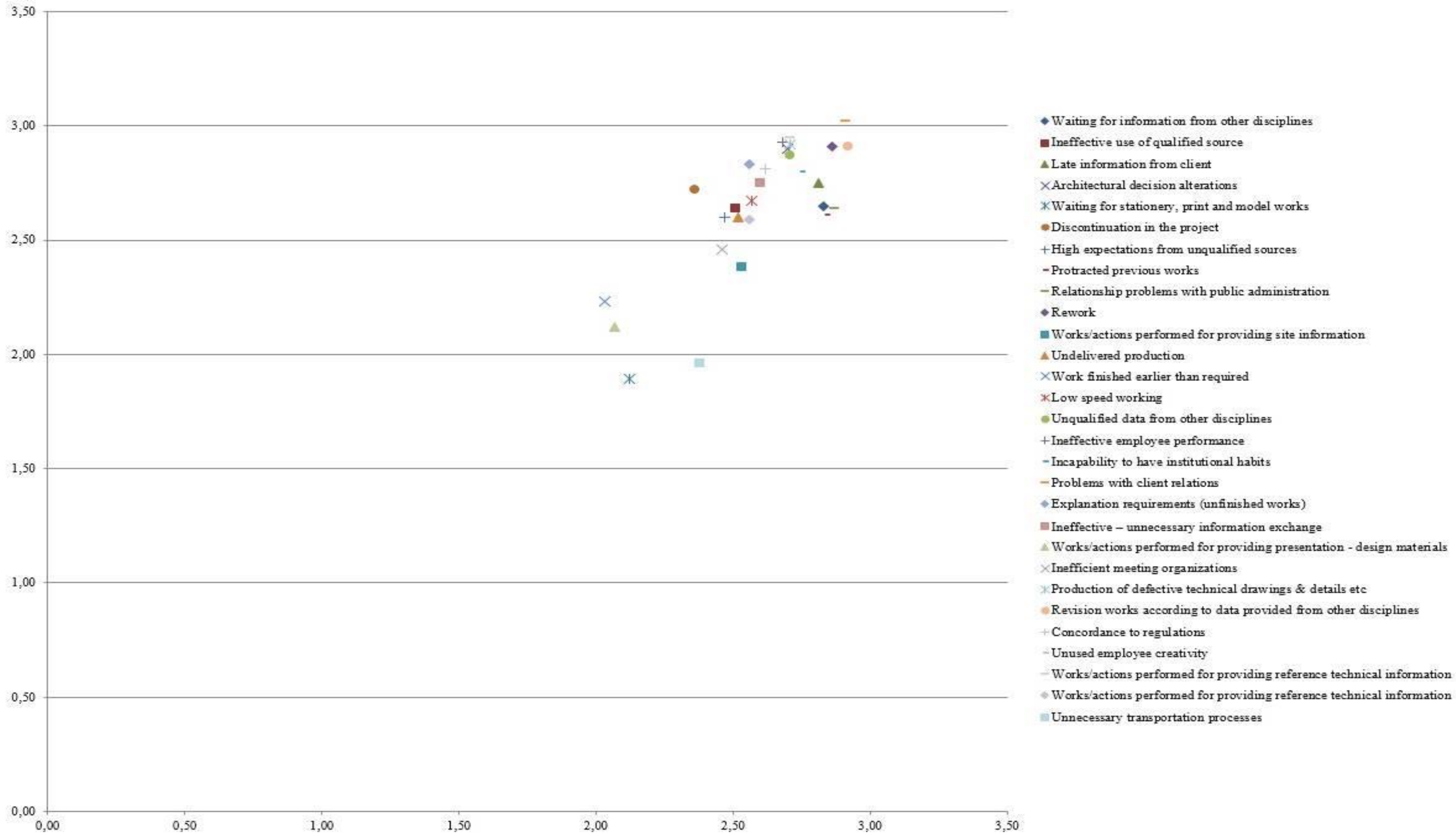


Figure 4.9 Distribution of waste items with respect to their *frequency of occurrence* and *impact over quality* mean values

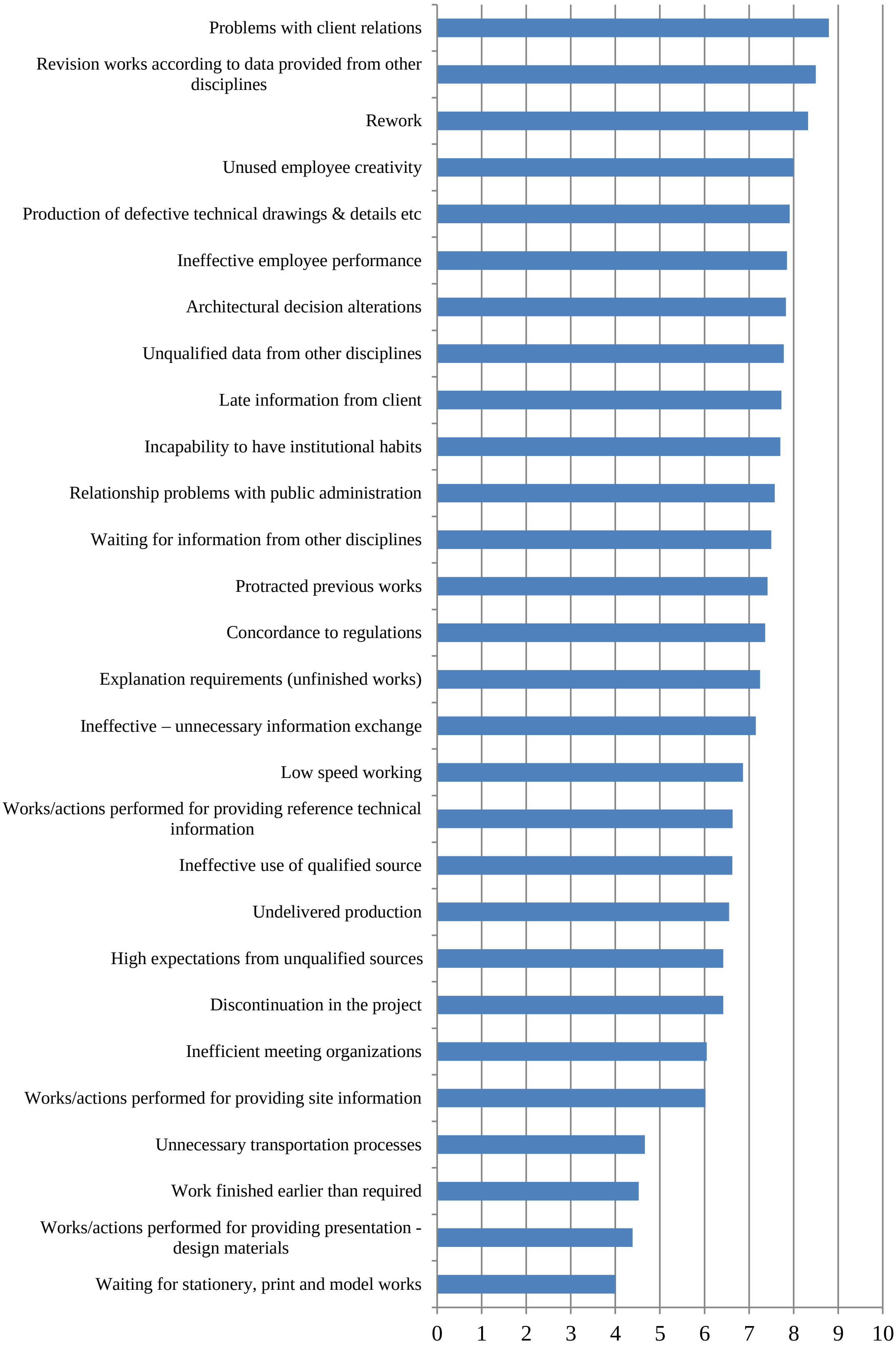


Figure 4.10 Waste item rankings according to their *quality risk value* scores

When three graphics of risk values for different project parameters (*cost, duration, quality*) are analyzed together, it is monitored that some waste items are emphasized by the answers of respondents in different manners. It is observed that:

"*rework*" is placed in first 3 rows;
"*revision works according to data provided from other disciplines*" is placed in first 4 rows;
"*waiting for stationery, print and model works*" is placed in last 2 rows;
"*work finished earlier than required*" is placed in last 3 rows;
"*works/actions performed for providing presentation - design materials*" is placed in last 3 rows and;
"*unnecessary transportation processes*" is placed in 4th row in all three rankings.

4.2.3 Comparison of Parameters

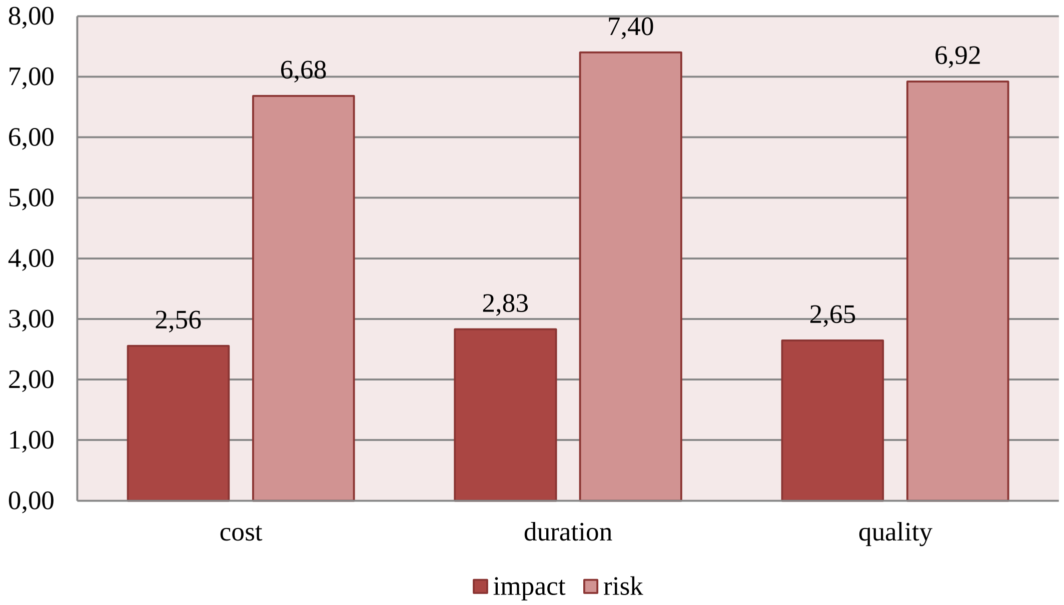


Figure 4.11 Mean scores for three project value parameters

The Figure illustrated above is prepared with mean scores of answers given by 151 respondents for 34 questions. As seen from the illustration, the respondents thought that the waste items listed in the questionnaire are mostly influential over the duration of the project. Quality and cost parameters follow duration respectively. The same grading is valid for risk value of each parameter similarly. So the thoughts of respondents can be expressed as:

impact over duration $\overline{x}$ = 2,83 > *impact over quality* $\overline{x}$ = 2,65 > *impact over cost* $\overline{x}$ = 2,56; and paralelly:
duration risk value $\overline{x}$ = 7,40 > *quality risk value* $\overline{x}$ = 6,92 > *cost risk value* $\overline{x}$ = 6,68.

4.2.4 Analysis of Respondents' Perspectives

Statistical tests were employed in SPSS 20 in order to determine whether there are meaningful relationships between the answers of questions in first and second sections of questionnaire. One way ANOVA tests are employed at the 5% level of significance ($\alpha = 0.05$) to determine whether there are any significant differences between population means of parameters' (*frequency of occurrence, impact over cost, impact over duration, impact over quality, cost risk value, duration risk value and quality risk value)* among the respondents given different answers to 5 questions (*personal experience, experience of organization, job position, annually performed work amount by the organization and number of personnel in organization*) in the first section of questionnaire.

By considering 5 different grouping questions in first section and 7 parameters to be compared, 35 null and alternative hypotheses were established for testing. However, none of the null hypotheses could have been rejected at the 5% level of significance because p-values are greater than $\alpha = 0.05$. Each hypothesis and the test results for can be found in Appendix C. Consequently there is no significant difference encountered on the answers of respondents that:

- have different amount of personnel experiences;
- work in organizations that have different number of years of experiences;
- work in different job positions;
- work in organizations that have different amount of work performed annually; and
- work in organizations that have different number of personnel.

4.2.5 Comparisons of Categories

After the evaluations in section 4.2.1 showed wastes from specific waste categories become prominent for different waste categories, it was decided to execute further statistical tests to investigate if there is a significant difference between the average scores of different waste categories. It should be noted that the comparisons made in this section are not based on individual scores of waste items. Instead, it is decided to calculate the average values by involving all waste items in each category and perform the comparisons according to obtained average waste category scores. It should be remarked that number of waste items in a waste category varies from 1 to 8. Waste items and categories can be seen in Table 3.1 in section 3.3 of this study.

One way within subjects ANOVA test is employed to determine whether there are any differences between population means of parameters' (*frequency of occurrence, impact over cost, impact over duration, impact over quality, cost risk value, duration risk value and quality risk value)* of different waste categories' (*overproduction, defects/correction, waiting, motion, inventory, overprocessing, unused employee creativity and transportation*) average scores at the 5% level of significance ($\alpha = 0.05$). Scores of each waste item in a waste category are involved in calculations for average values. Seven statistical hypotheses for each parameter with descriptive explanations of results are presented below. The tables showing results of multivariate tests and post hoc comparisons for all hypotheses are given in Appendix D.

Hypothesis I:

Null Hypothesis: There is no significant difference between population means of *frequency of occurrence* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots. = \mu_8$

H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *frequency of occurrence* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,53, F(2,3) = 18,35, p = 0,00 - null hypothesis, $H_{0,}$ is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *frequency of occurrence* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.1.

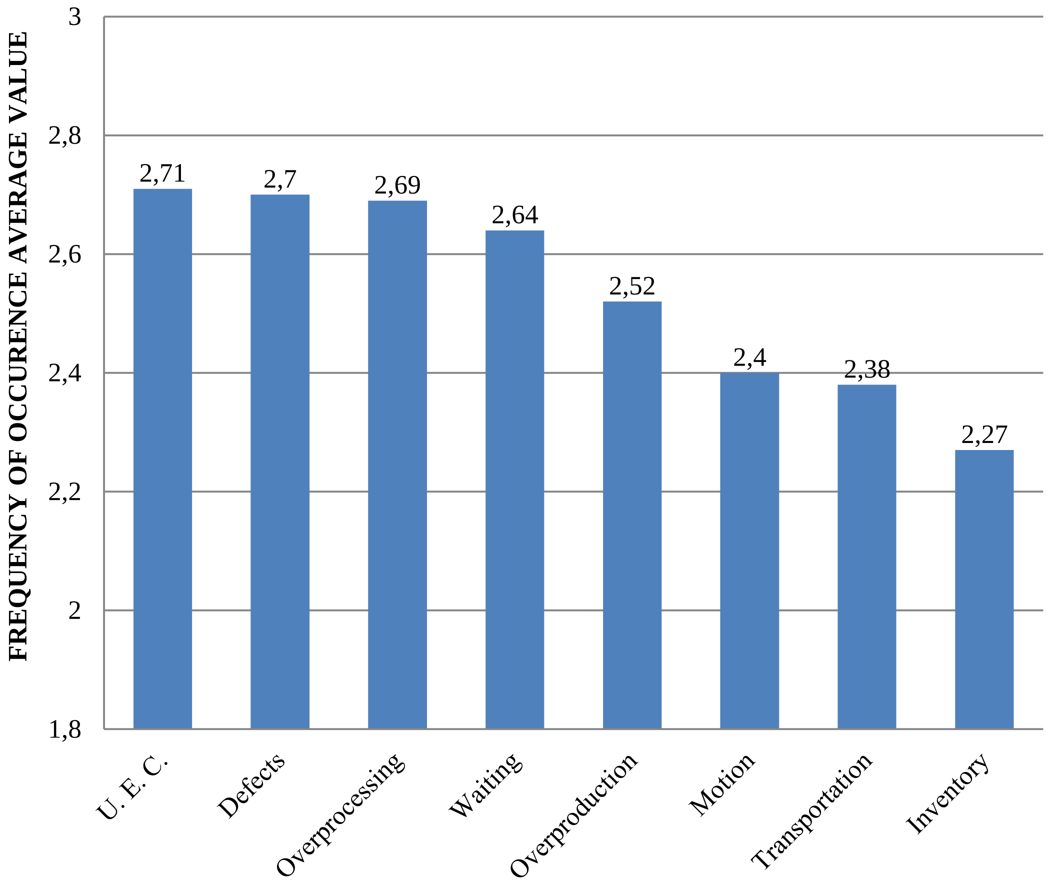


Figure 4.12 Significant differences between population means of f*requency of occurrence* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.12. According to data derived from comparison, average value for *frequency of occurrence* score of:

- *Unused Employee Creativity* $\bar{x}$ = 2,71 (SD = 0,063), *Defects / Correction* $\bar{x}$ = 2,70 (SD = 0,042), *Overprocessing* $\bar{x}$ = 2,69 (SD = 0,040), and *Waiting* $\bar{x}$ = 2,64 (SD = 0,032) categories are significantly higher than *Motion* $\bar{x}$ = 2,40 (SD = 0,041), *Transportation* $\bar{x}$ = 2,38 (SD = 0,068) *and Inventory* $\bar{x}$ = 2,27 (SD = 0,042) categories, and
- *Overproduction* $\bar{x}$ = 2,52 (SD = 0,064) category is significantly higher than *Inventory* $\bar{x}$ = 2,27 (SD = 0,042) category.

There is no other significant difference between *frequency of occurrence* scores of different waste categories' average scores.

Hypothesis II:

Null Hypothesis: There is no significant difference between population means of *impact over cost* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots. = \mu_8$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *impact over cost* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,46, F(2,3) = 24,60, p = 0,00 - null hypothesis, $H_{0,}$ is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *impact over cost* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.2.

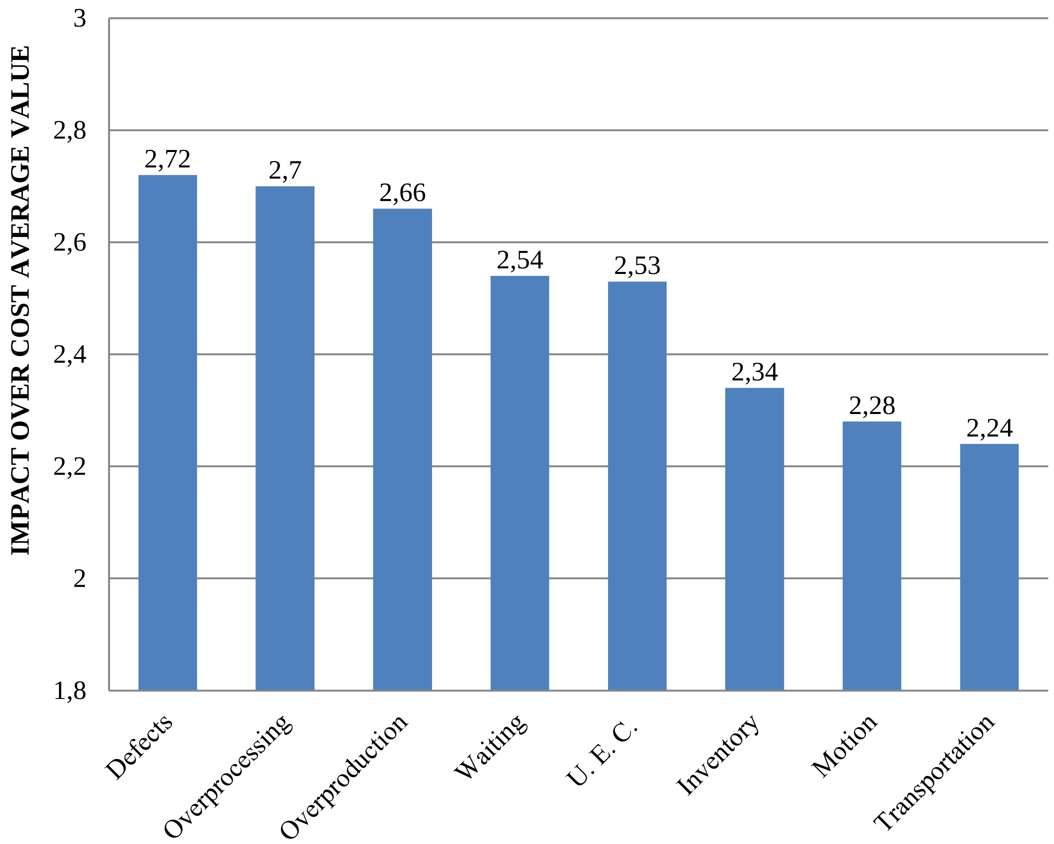


Figure 4.13 Significant differences between population means of *impact over cost* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.13. According to data derived from comparison, average value for *impact over cost* score of:

- *Defects / Correction* $\bar{x}$ = 2,72 (SD = 0,045) and *Overprocessing* $\bar{x}$ = 2,70 (SD = 0,044) categories are significantly higher than *Waiting* $\bar{x}$ = 2,54 (SD = 0,041), *Inventory* $\bar{x}$ = 2,34 (SD = 0,050), *Motion* $\bar{x}$ = 2,28 (SD = 0,046) *and Transportation* $\bar{x}$ = 2,24 (SD = 0,068) categories;
- *Overproduction* $\bar{x}$ = 2,66 (SD = 0,069) and *Waiting* $\bar{x}$ = 2,54 (SD = 0,041) categories are significantly higher than *Inventory* $\bar{x}$ = 2,34 (SD = 0,050), *Motion* $\bar{x}$ = 2,28 (SD = 0,046) *and Transportation* $\bar{x}$ = 2,24 (SD = 0,068) categories, and

- *Unused Employee Creativity* $\bar{x}$ = 2,53 (SD = 0,068) category is significantly higher than *Motion* $\bar{x}$ = 2,28 (SD = 0,046) and *Transportation* $\bar{x}$ = 2,24 (SD = 0,068) categories.

There is no other significant difference between *impact over cost* scores of different waste categories' average scores.

Hypothesis III:

Null Hypothesis: There is no significant difference between population means of *impact over duration* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots = \mu_8$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *impact over duration* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,40 , F(2,3) = 31,01, p = 0,00 - null hypothesis, H_0, is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *impact over duration* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.3.

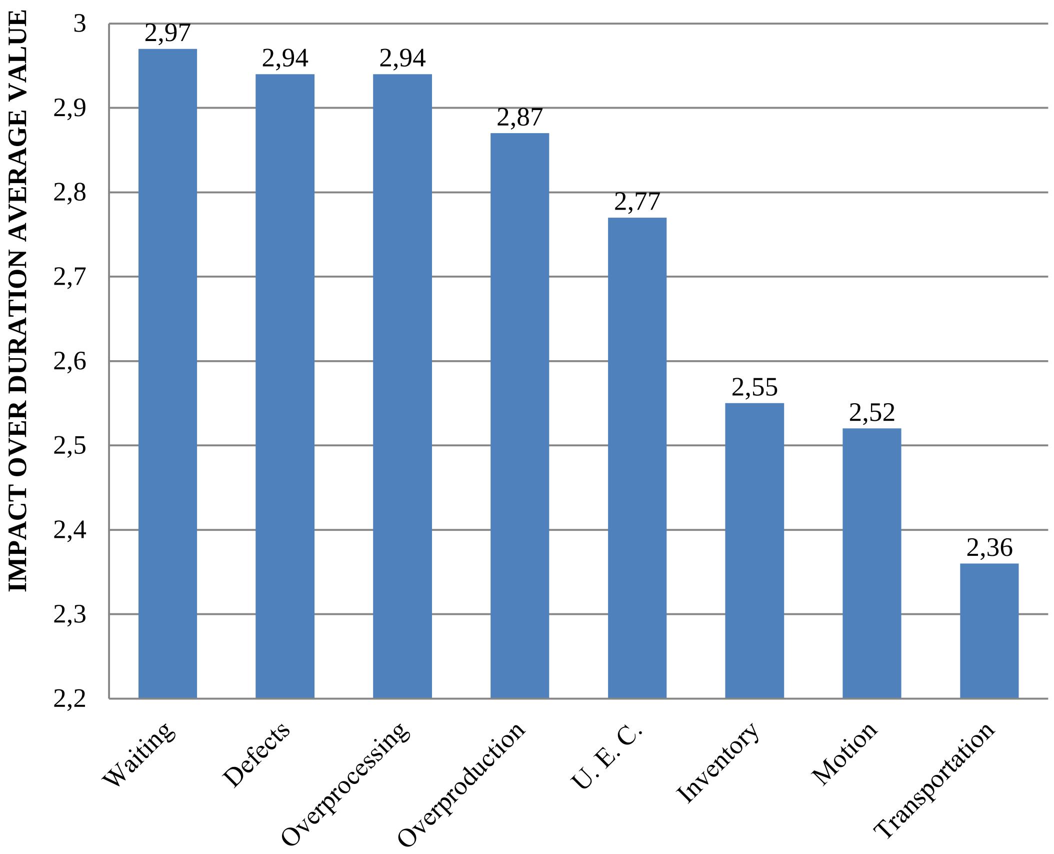


Figure 4.14 Significant differences between population means of *impact over duration* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.14. According to data derived from comparison, average value for *impact over duration* score of:

- *Waiting* $\bar{x}$ = 2,97 (SD = 0,038), *Overprocessing* $\bar{x}$ = 2,94 (SD = 0,044), *Defects / Correction* $\bar{x}$ = 2,94 (SD = 0,044) and *Overproduction* $\bar{x}$ = 2,87 (SD = 0,071) categories are significantly higher than *Inventory* $\bar{x}$ = 2,55 (SD = 0,049), *Motion* $\bar{x}$ = 2,52 (SD = 0,045) *and Transportation* $\bar{x}$ = 2,36 (SD = 0,070) categories, and
- *Unused Employee Creativity* $\bar{x}$ = 2,77 (SD = 0,071) category is significantly higher than *Motion* $\bar{x}$ = 2,52 (SD = 0,045) *and Transportation* $\bar{x}$ = 2,36 (SD = 0,070) categories.

There is no other significant difference between *impact over duration* scores of different waste categories' average scores.

Hypothesis IV:

Null Hypothesis: There is no significant difference between population means of *impact over quality* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots . = \mu_8$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *impact over quality* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,37, F(2,3) = 35,22, p = 0,00 - null hypothesis, $H_{0,}$ is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *impact over quality* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.4.

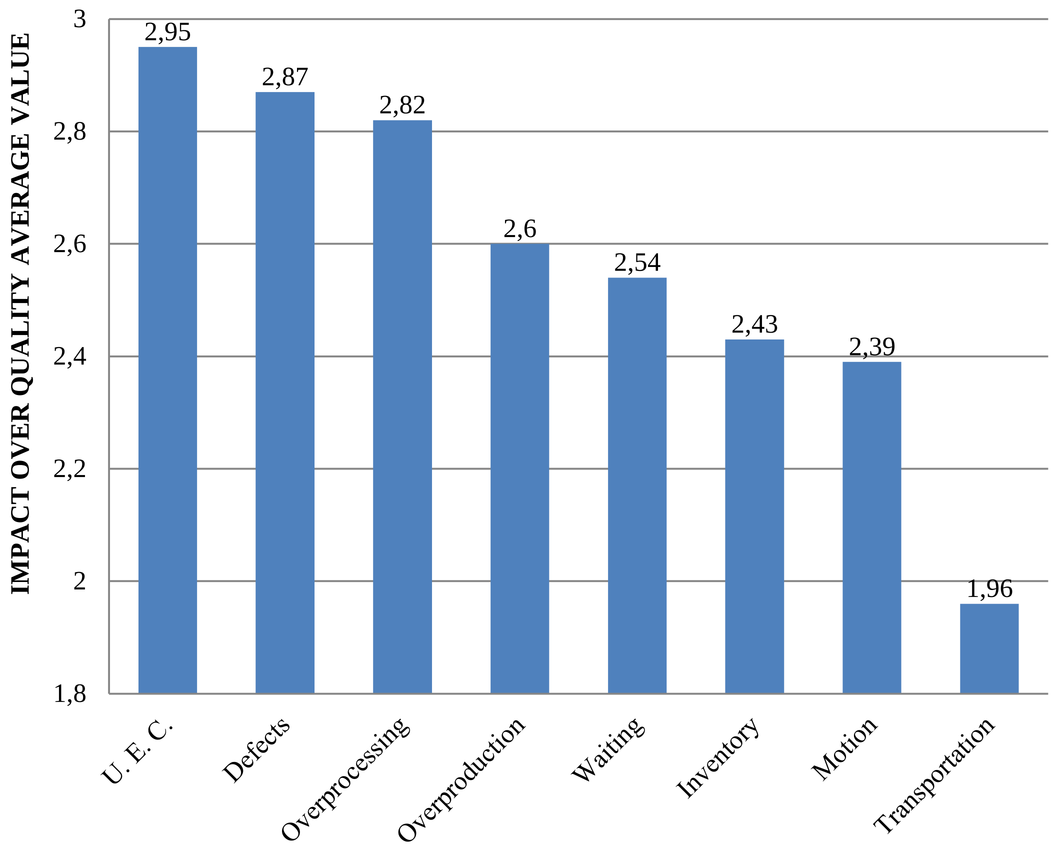


Figure 4.15 Significant differences between population means of *impact over quality* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.15. According to data derived from comparison, average value for *impact over quality* score of:

- *Unused Employee Creativity* $\bar{x}$ = 2,95 (SD = 0,065), *Defects / Correction* $\bar{x}$ = 2,87 (SD = 0,050), *Overprocessing* $\bar{x}$ = 2,82 (SD = 0,046), *Overproduction* $\bar{x}$ = 2,60 (SD = 0,072), *Waiting* $\bar{x}$ = 2,54 (SD = 0,041), *Inventory* $\bar{x}$ = 2,43 (SD = 0,055) and *Motion* $\bar{x}$ = 2,39 (SD = 0,047) categories are significantly higher than *Transportation* $\bar{x}$ = 1,96 (SD = 0,066) category;
- *Unused Employee Creativity* $\bar{x}$ = 2,95 (SD = 0,065), *Defects / Correction* $\bar{x}$ = 2,87 (SD = 0,050) and *Overprocessing* $\bar{x}$ = 2,82 (SD = 0,046) categories are significantly higher than *Overproduction* $\bar{x}$ = 2,60 (SD = 0,072), *Waiting* $\bar{x}$ =

2,54 (SD = 0,041), *Inventory* $\bar{x}$ = 2,43 (SD = 0,055) and *Motion* $\bar{x}$ = 2,39 (SD = 0,047) categories, and

- *Waiting* $\bar{x}$ = 2,54 (SD = 0,041) category is significantly higher than *Motion* $\bar{x}$ = 2,39 (SD = 0,047) category.

There is no other significant difference between *impact over quality* scores of different waste categories' average scores.

Hypothesis V:

Null Hypothesis: There is no significant difference between population means of *cost risk value* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots = \mu_8$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *cost risk value* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,48, F(2,3) = 21,93, p = 0,00 - null hypothesis, H_0, is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *cost risk value* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.5.

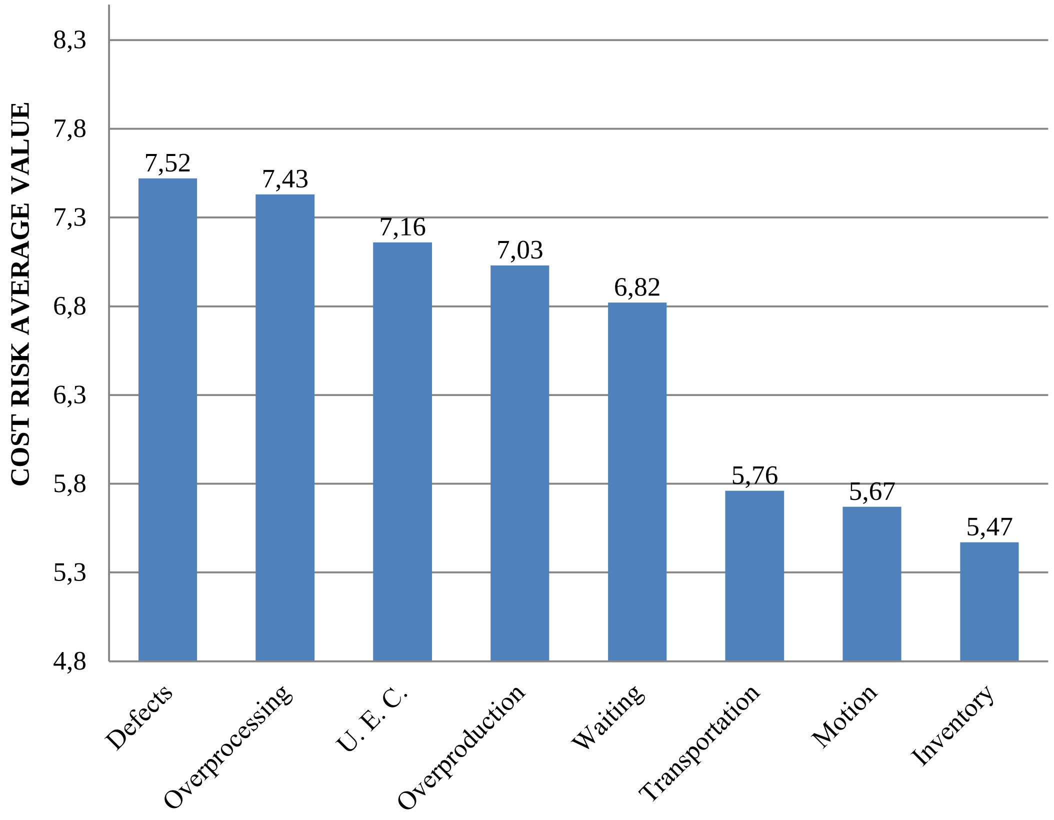


Figure 4.16 Significant differences between population means of *cost risk value* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.16. According to data derived from comparison, average value for *cost risk value* score of:

- *Defects / Correction* $\bar{x}$ = 7,52 (SD = 0,22) and *Overprocessing* $\bar{x}$ = 7,43 (SD = 0,20) categories are significantly higher than *Waiting* $\bar{x}$ = 6,82 (SD = 0,17), *Transportation* $\bar{x}$ = 5,76 (SD = 0,30) *Motion* $\bar{x}$ = 5,67 (SD = 0,19) and *Inventory* $\bar{x}$ = 5,47 (SD = 0,19) categories, and
- *Unused Employee Creativity* $\bar{x}$ = 7,16 (SD = 0,32) category is significantly higher than *Transportation* $\bar{x}$ = 5,76 (SD = 0,30) *Motion* $\bar{x}$ = 5,67 (SD = 0,19) and *Inventory* $\bar{x}$ = 5,47 (SD = 0,19) categories.

There is no other significant difference between *cost risk* scores of different waste categories' average scores.

Hypothesis VI:

Null Hypothesis: There is no significant difference between population means of *duration risk value* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots. = \mu_8$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *duration risk value* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,45, F(2,3) = 25,13, p = 0,00 - null hypothesis, $H_{0,}$ is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *duration risk value* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.6.

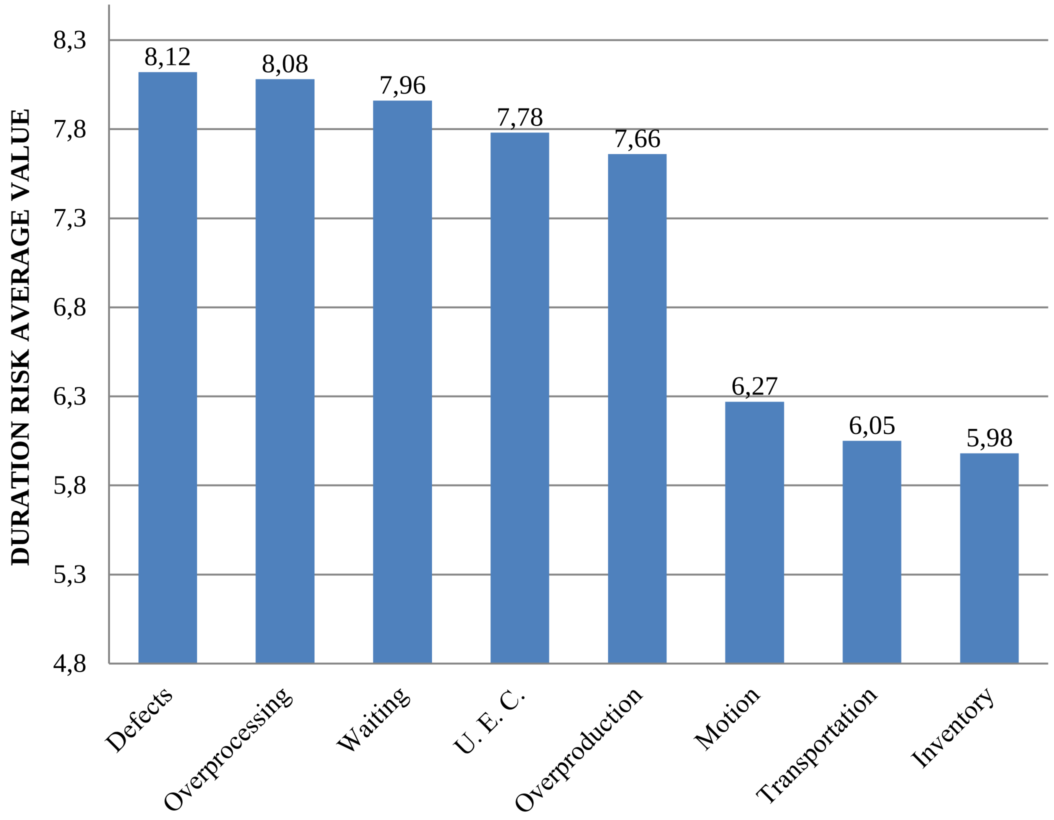


Figure 4.17 Significant differences between population means of *duration risk value* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.17. According to data derived from comparison, average value for *duration risk* score of:

- *Defects / Correction* $\bar{x}$ = 8,12 (SD = 0,22) and *Overprocessing* $\bar{x}$ = 8,08 (SD = 0,21) *Waiting* $\bar{x}$ = 7,96 (SD = 0,18), *Unused Employee Creativity* $\bar{x}$ = 7,78 (SD = 0,32) and *Inventory* $\bar{x}$ = 5,98 (SD = 0,20) categories are significantly higher than *Motion* $\bar{x}$ = 6,27 (SD = 0,20), *Transportation* $\bar{x}$ = 6,05 (SD = 0,30) and *Inventory* $\bar{x}$ = 5,98 (SD = 0,20) categories.

There is no other significant difference between *duration risk value* scores of different waste categories' average scores.

Hypothesis VII:

Null Hypothesis: There is no significant difference between population means of *quality risk value* scores of different waste categories' average values

Alternative Hypothesis: At least one waste category's average score of population mean is significantly different from the others.

H_0: $\mu_1 = \ldots = \mu_8$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5,6,7,8) refers to the population means of *quality risk value* scores of different waste categories' average scores.

According to test results - Wilks' Lambda = 0,43, F(2,3) = 27,79, p = 0,00 - null hypothesis, $H_{0,}$ is rejected because p - value is smaller than 0,05. And it is concluded that at least one waste category's average value is significantly different from others in terms of population mean of *quality risk value* parameter. Hence it is further questioned which waste category has particularly different average values from others. Bonferroni post hoc test was employed for comparisons between waste categories. Detailed results of tests are given in Appendix D.7.

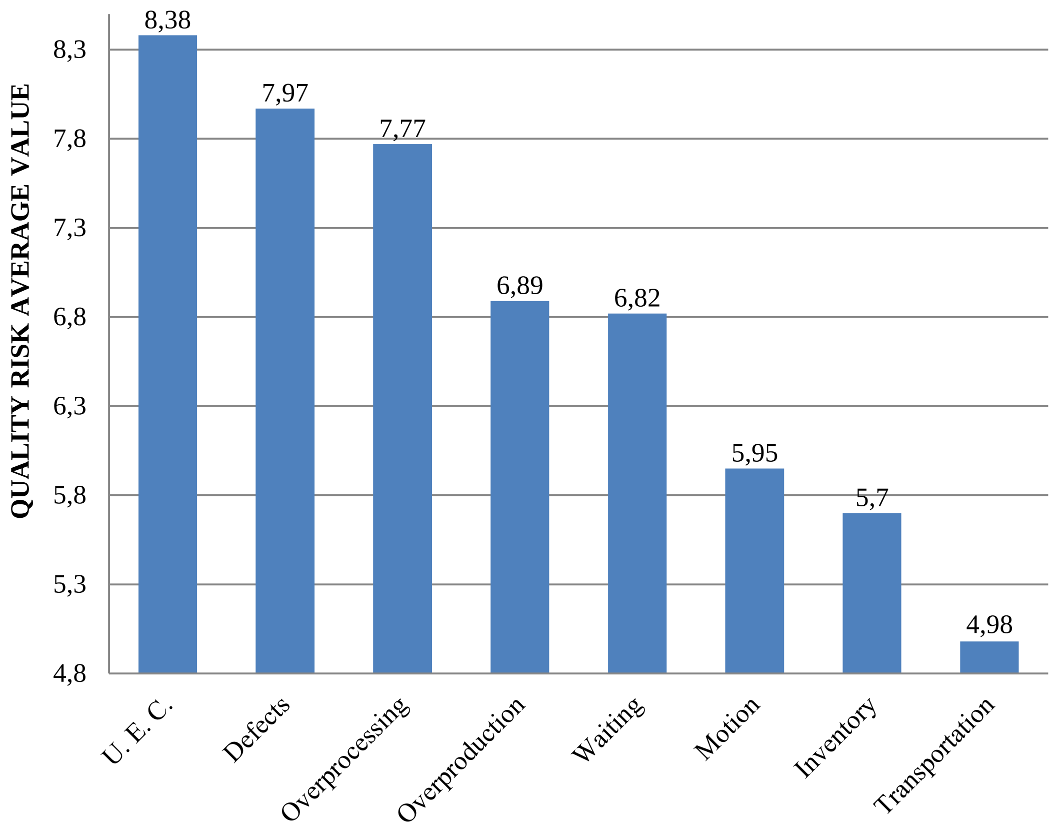


Figure 4.18 Significant differences between population means of *quality risk value* scores of different waste categories' average values

Main results of pairwise comparison are illustrated in Figure 4.18. According to data derived from comparison, average value for *quality risk* score of:

- *Unused Employee Creativity* $\bar{x}$ = 8,38 (SD = 0,34), *Defects / Correction* $\bar{x}$ = 7,97 (SD = 0,24) and *Overprocessing* $\bar{x}$ = 7,77 (SD = 0,21) categories are significantly higher than *Overproduction* $\bar{x}$ = 6,89 (SD = 0,31), *Waiting* $\bar{x}$ = 6,82 (SD = 0,17), *Motion* $\bar{x}$ = 5,95 (SD = 0,20), *Inventory* $\bar{x}$ = 5,70 (SD = 0,20) and *Transportation* $\bar{x}$ = 4,98 (SD = 0,28) categories;
- *Overproduction* $\bar{x}$ = 6,89 (SD = 0,31) and *Waiting* $\bar{x}$ = 6,82 (SD = 0,17) categories are significantly higher than *Inventory* $\bar{x}$ = 5,70 (SD = 0,20) and *Transportation* $\bar{x}$ = 4,98 (SD = 0,28) categories, and

- *Motion* $\bar{x}$ = 5,95 (SD = 0,20) category is significantly higher than *Transportation* $\bar{x}$ = 4,98 (SD = 0,28) category.

There is no other significant difference between *quality risk value* scores of different waste categories' average scores.

In this section, the waste items were not compared individually. All the calculations, comparisons and evaluations were made over the average values of the waste items in 8 different waste categories. Number of items in each waste category varies from 1 to 8. In general, it is noted that different waste categories became prominent with respect to the parameter questioned.

According to respondents, *unused employee creativity* $\bar{x}$ = 2,71 (SD = 0,063) has the highest value in *probability of occurrence* with its only waste item by surpassing average values of all waste categories. Similarly, average of waste items in *defects/correction* $\bar{x}$ = 2,72 (SD = 0,045) category is the highest one for *impact over project cost*; while average of waste items in *waiting* $\bar{x}$ = 2,97 (SD = 0,038) category is the highest one for *impact over project duration* and finally, the score of *unused employee creativity* $\bar{x}$ = 2,95 (SD = 0,065) waste item is higher than average value of all other waste categories by considering its *impact over project quality*.

In addition, average value of waste items under *defects/correction* $\bar{x}$ = 7,52 (SD = 0,22); $\bar{x}$ = 8,12 (SD =0,22); category has the highest score in both *cost* and *duration risk value* parameters respectively. On the other hand, none of the categories' average value could have reached the score of only waste item in *unused employee creativity* $\bar{x}$ = 8,38 (SD = 0,34) in terms of *quality risk value parameter*.

On the other hand, the average values of wastes in *motion*, *inventory* and *transportation* categories have significantly lower scores when compared to other 5 waste categories. Similarly, the average values of waste items under those categories shared last 3 rows in all 7 parameter scores.

CHAPTER 5

CONCLUSION

In this chapter, a summary of the work is presented firstly as a brief overview including the aim and methodology of the study. Next, main results are highlighted and a discussion is made for utilizing the output data for professional practice. Lean principles from the literature are involved in the discussion. Then, limitations of the study are mentioned. Finally, the chapter is concluded with recommendations for further possible researches.

5.1 Summary of the Research

Efficiency increase in construction industry is progressing with a different momentum when compared to other manufacturing industries. This situation has numerous acceptable reasons such as: high number of design and planning decisions per product, inability to determine and predict conditions of production environment, long-term production phases and hardness of automating production line.

If increasing the efficiency of production is questioned, it is considered that the starting point should be addressed as determining the causes of inefficiencies. In the light of literature review, it was recognized that waste can be defined from different point of views with different approaches. In the beginning of literature review section, waste management and construction relationship is discussed. In this section of the study, the importance of waste management, classification of waste, sources of wastes, design and waste relationship, construction waste management strategies and habits of construction industry in waste management are presented. It is further noticed that the variation of waste definitions in the literature origins from focusing on different sources' (*i.e.*, material, time, labor *etc*.) consumption values.

At this point the waste definition of lean thinking is internalized as the most inclusive one being considered as the most appropriate for defining the sources of inefficiencies in construction and architectural design industry. As a widely accepted definition made by Koskela (1992): "any inefficiency that results in the use of equipment, materials, labor or capital in larger quantities than those considered as necessary in the production of a building" is waste.

Then the studies were concentrated around lean thinking and lean construction relationship. Being accepted as founder and first practitioner of the lean philosophy - Toyota Production System was investigated, 8 waste categories and lean principles were given place. The research is continued with the definitions of LC, a brief history of LC, key LC concepts and LPDS were presented in the body of literature review.

During the research, the deep relationship between the efficiency of architectural design and construction phases was confirmed. On the other hand, it was observed that less effort was spent by literature for understanding the problems and inefficiencies of architectural design processes. Therefore, it is thought that there is a big gap in the literature to be studied for increasing the efficiency of design phase. In order to contribute for a framework generation for architectural design industry, it is decided to focus on determining waste items of architectural design and their impact over project value parameters.

Within the aforementioned research structure, the reflections of lean thinking's “8 Waste Categories” on architectural design practice are investigated. The research is consisted up of two main phases. In the first phase, waste items and their sources were determined via interviews conducted with 8 architect/managers performing in design industry for at least ten years. Then 28 determined waste items’ frequency of occurrence and impact over three project value parameters (cost, duration and quality) are investigated with the involvement of a wider population (a total of 151 members from Chamber of Architects Ankara Branch).

In this methodology,

- current wastes in design process were compiled,
- lean design waste items were grouped under 8 waste categories,
- frequency of occurrence, impact over cost, impact over duration and impact over quality parameters for each waste item were evaluated,
- waste items that are highly effective in reducing project value were found, and
- impact of waste categories for different value parameters were evaluated.

In next section, a summary of the main results reached in this study is given. And by associating lean principles and waste sources; a brief introduction is made for generating a roadmap for architectural design industry.

5.2 Main Results and Discussion

The evaluation of interviews - which is the first phase of the study - revealed 28 lean design waste items under 8 waste categories. Furthermore, 59 different waste sources were stated 141 times by interviewees. All waste items had at least two sources while top number of sources for a waste item was 13. Some sources are repeated up to 8 times while some of them stated only once. That means some of the sources can lead up to 8 different waste items noted by the respondents.

In the next phase, the evaluation of questionnaire is performed. Firstly, waste items were compared according to four parameters directly asked in survey. "Revision works according to data provided from other disciplines", "problems with client relations", "relationship problems with public administration", "rework" and "protracted previous works" were stated as the most frequently occurred waste items.

When impact over project cost is in question, "rework" is placed in the first place and followed by "ineffective employee performance", "architectural decision alterations", "revision works according to data provided from other disciplines" and "problems with client relations".

"Rework" addressed by the respondents as the most effective waste item over increasing project duration. "Discontinuation in the project", "late information from client", "relationship problems with public administration" and "protracted previous works" were other prominent ones.

The waste items that causes decrease in project quality were lined as "problems with client relations", "unused employee creativity", "ineffective employee performance", production of defective technical drawings and details *etc*." and "revision works according to data provided from other disciplines".

Then the evaluation is continued with risk values determined by multiplication of frequency of occurrence and impact scores. Detailed evaluation can be found in 4.2.2. To sum up; when risk values for different project parameters (*cost, duration, quality*) are analyzed together, it is monitored that some waste items are emphasized by the answers of respondents in different manners. It is observed that:

- "*rework*" is placed in first 3 rows;
- "*revision works according to data provided from other disciplines*" is placed in first 4 rows;
- "*waiting for stationery, print and model works*" is placed in last 2 rows;
- "*work finished earlier than required*" is placed in last 3 rows;
- "*works/actions performed for providing presentation - design materials*" is placed in last 3 rows and;
- "*unnecessary transportation processes*" is placed in 4th row in all three rankings.

In order to achieve an absolute lean architectural design process, all waste items should be eliminated. However, it can be a right decision to focus on the items that have highest negative impact over project value parameters (cost, duration and quality) and work for eliminating their sources.

In this manner, it can be captured that 9 waste items share first five rows in three different risk value tables: "rework", "revision works according to data provided from other disciplines", "problems with client relations", "relationship problems with public administrations", "architectural design alterations", "late information from client", "protracted previous works", "unused employee creativity" and "production of defective technical drawings and details *etc*. "The sources of waste items in question are presented in Table 5.1.

Table 5.1 Waste sources of 9 most effective waste items

ill planned process organization (4)[7]	*ineffective feasibility study from client (1)*
inability to provide employee continuity (3)	*unnecessary information interchange in meetings (1)*
insufficient feasibility study (3)	*insufficient information sharing of stakeholders (1)*
architects' lack of knowledge about the buildings' function and operation and site applications (3)	*not expecting employees to make philosophical contribution and take responsibility (1)*
hardness to professionalize on a specific task (3)	*waiting for obtaining site document (1)*
not use of written documents for decisions (2)	*problems about public funds in public projects (1)*
lack of self-evaluation of the organization (2)	*ineffective controlling and monitoring of process (1)*
ineffective direction of client (2)	*delayed decisions of client (1)*
incorrect and unclear input from client (2)	*insufficient authority sharing - owner based system (1)*
clients' rash to start construction (2)	*phase waiting for lacking information (1)*
unwillingness to allocate sources for new attitudes (2)	*discrepancy of "value" concept for client and designers (1)*
employees not feeling as an important part of the organization (2)	*client not paying enough attention for project phase (1)*
waste accepted as inevitable (1)	*designers not caring the application problems/cost (1)*
inability of co-operation between all the disciplines from commencement of the project (1)	*extremely limited time allowed for architectural design project production (1)*
desire of client to work with a particular engineering team (1)	*organization's unawareness of possessed source quality (1)*
jumping to next phase before necessary information reached from other disciplines (1)	*frequent personnel changes in especially local administrations (1)*
not following the innovations on the industry (1)	*unqualified and missing organization chart (1)*
stakeholders' lack of core knowledge about different disciplines (1)	*unawareness of the employee about his/her own qualifications (1)*

[7] numbers in paranthesis indicate number of waste items affected by the sources

Although a difference in responses of architects having different professional backgrounds (such as architects working in different positions, having different experience levels, working in different experience leveled companies *etc*.) was searched, no statistically significant variation has been founded.

Further statistical tests performed for determining whether there is a significant difference between the average scores of waste categories. According to respondents, "*unused employee creativity"* $\overline{x}$ = 2,71 (SD = 0,63) has the highest value in *probability of occurrence* with its only waste item by surpassing average values of all waste categories. Similarly, average of waste items in "*defects/correction"* $\overline{x}$ = 2,72 (SD = 0,45) category is the highest one for *impact over project cost*; while average of waste items in "*waiting"* $\overline{x}$ = 2,97 (SD = 0,38) category is the highest one for *impact over project duration* and finally, the score of "*unused employee creativity"* $\overline{x}$ = 2,95 (SD = 0,65) waste item is higher than average value of all other waste categories by considering its *impact over project quality*.

In addition, average value of waste items under "*defects/correction"* $\overline{x}$ = 7,52 (SD = 0,31); $\overline{x}$ = 8,12 (SD =0,22); category has the highest score in both *cost* and *duration risk value* parameters respectively. On the other hand, none of the categories' average value could have reached the score of only waste item in "*unused employee creativity"* $\overline{x}$ = 8,38 (SD = 0,34) in terms of quality risk value parameter.

On the other hand, the average values of wastes in *motion*, *inventory* and *transportation* categories have significantly lower scores when compared to other 5 waste categories. Similarly, the average values of waste items under those categories shared last 3 rows in all 7 parameter scores.

5.3 Limitations of the Study

There were limitations of the study to be mentioned. Firstly, the number of interviews was limited to eight, due to restricted time and availability of design offices. Obviously conducting more interviews might have contributed for achieving closer results to a universal waste item - sources catalog. Another limitation of the study was related with the scope of questionnaire. A survey applied on a greater population involving more architects from all over the country could have given more exact and accurate results. However, the bureaucratic difficulties for obtaining e-mail addresses and time restriction prevented a wider research execution and the material of survey analysis were limited to 151 fully answered responds.

5.4 Recommendations for Further Research

This study mainly provides the waste items and sources catalog for architectural design process. Then investigates and evaluates their frequency of occurrences and impacts over different project value parameters. The findings of this study can be seen as the first step for the aim of increasing the efficiency of architectural design process with a lean perspective.

The relationship between waste sources and lean principles and tools is briefly mentioned in this research. Future studies may evaluate such relationships in a detailed manner. Possible works investigating lean principles and tools to be employed for eliminating the waste items presented in this study may be helpful for the adaptation of lean philosophy through architectural design industry.

In this study, design process was evaluated from architectural point of view only. By considering contemporary project delivery methods, another future research area may be to evaluate architecture – engineering and design – construction issues together. Such integration scenarios may open the way for increasing the efficiency and create new possible waste prevention strategies.

Furthermore, the relationships between the waste items and their impact over construction phase may be investigated. By considering the sensitivity of decision makers in the industry is directed towards construction works, it may be constitutive for design industry to establish the relationships of lean design waste items and their possible consequences in construction phase of projects.

REFERENCES

Abdelhamid, T. & Mossman, A., 2004. Editor's Note. *Lean Construction Journal*, 1, pp.i–iii.

Al-Aomar, R., 2012. Analysis of lean construction practices at Abu Dhabi construction industry. *Lean Construction Journal*, pp.105–121.

Alinaitwe, H.M., 2009. Prioritising Lean Construction Barriers in Uganda's Construction Industry. *Journal of Construction in Developing Countries*, 14(1), pp.15–30.

Andersen, B., Belay, A.M. & Seim, E.A., 2012. Lean Construction Practices and its Effects : A Case Study at St Olav's Integrated Hospital, Norway. *Lean Construction Journal*, pp.122–149.

Andrew, B.N. et al., *REDUCING WASTE IN HIGH-RISE RESIDENTIAL BUILDINGS BY INFORMATION MODELLING AT THE DESIGN STAGE*,

Anon, 2004. *A best practice guide for the construction industry*, Available at: http://212.69.36.161/pdf/document/Teamwork_Guide.pdf [Accessed June 11, 2015].

Arch, D. et al., 2006. Architect and Contractor Attitudes to Waste Minimisation. *Proceedings of the ICE - Waste and Resource Management*, 159(May), pp.65–72.

Arditi, D., Akan, G.T. & Gürdamar, S., 1985. Reasons for delays in public projects in Turkey. *Construction Management and Economics*, 3, pp.171–181.

Atkinson, P. & Hammersley, M., 2007. *Ethnography: Principles and Practice*,

Austin, S. et al., 1999. Analytical Design Planning Technique: a model of the detailed building design process. *Design Studies*, 20(3), pp.279–296.

Austin, S.A., Baldwin, A.N. & Steele, J.L., 2002. Improving building design through integrated planning and control. *Engineering, Construction and Architectural Management*, 9(3), pp.249–258.

Aziz, R.F. & Hafez, S.M., 2013. Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal*, 52, pp.679–695.

Baldwin, A. et al., 2007. Reducing Construction Waste by Decisions within the Design Process. In *CIB World Building Congress 2007*. pp. 2568–2583.

Baldwin, A.N. et al., 2008. Modelling design information to evaluate pre-fabricated and pre-cast design solutions for reducing construction waste in high rise residential buildings. *Automation in Construction*, 17(3), pp.333–341. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0926580507000738 [Accessed August 15, 2014].

Ballard, G., 2002. Managing work flow on design projects: a case study. *Engineering, Construction and Architectural Management*, 9(3), pp.284–291

Ballard, G., 2008. The Lean Project Delivery System : An Update. *Lean Construction Journal*, 8, pp.1–19. Available at: http://www.leanconstruction.org/media/library/id53/The_Lean_Project_Delivery_System_An_Update.pdf [Accessed June 12, 2015].

Ballard, G. & Zabelle, T., 2000. Project definition. In *LCI White Paper #9*. Lean Construction Institute, p. 10pp.

Bertelsen, S., 2004. LEAN CONSTRUCTION : WHERE ARE WE AND HOW TO PROCEED ? *Lean Construction Journal*, 1(October), pp.46–69.

Blanchard, K., 2004. *The One Minute Manager Builds High Performing Teams* Paperback, London: Harper Collins Publishers.

Bossink, B.A.G. & Brouwers, H.J.., 1996. Construction waste: quantification and source evaluation. *Journal of Construction Engineering and Management*, March, pp.55–60.

Bossink, B.A.G. & Brouwers, H.J.H., 1996. Construction Waste: Quantification and Source Evaluation. *Journal of Construction Engineering and Management*, 122, pp.55–60.

Charmaz, K., 1995. Between positivism and postmodernism: implications for methods. In *Studies in Symbolic Interaction*. pp. 42–72.

Cherns, A.B. & Bryant, D.T., 1984. Studying the client's role in construction management. *Construction Management and Economics*, 2, pp.177–184.

Cretu, O., Stewart, R. & Berends, T., 2011. *Risk Management for Design and Construction*, London: Wiley - Blackwell.

Cullen, P. et al., 2005. The Application Of Lean Principles To In-Service Support : A Comparison Between Construction And The Aerospace And Defence Sectors Overview of the Lean Principles. *Lean Construction Journal*, 2(April), pp.87–104.

Dumbravă, V. & Iacob, V.-S., 2013. Using Probability–Impact Matrix in Analysis and Risk Assessment Projects. *Journal of Knowledge Management, Economics* *and Information Technology*, (December), pp.76–96. Available at: http://www.scientificpapers.org/wp-content/files/07_Dumbrava_Iacob-USING_PROBABILITY__IMPACT_MATRIX_IN__ANALYSIS_AND_RISK_ASSESSMENT_PROJECTS.pdf [Accessed June 12, 2015].

Eastman, C. et al., 2011. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, John Wiley & Sons Inc. Available at: http://www.academia.edu/3183272/BIM_handbook_A_guide_to_building_information_modeling_for_owners_managers_designers_engineers_and_contractors [Accessed June 12, 2015]

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *Academy of Management Review*, 14, pp.532–550.

El. Reifi, M.H. & Emmitt, S., 2013. Perceptions of lean design management. *Architectural Engineering and Design Management*, 9, pp.195–208. Available at: http://www.tandfonline.com/doi/abs/10.1080/17452007.2013.802979 [Accessed June 12, 2015].

Emmitt, S., Pasquire, C. & Mertia, B., 2012. Is good enough "making do"?: An investigation of inappropriate processing in a small design and build company. *Construction Innovation*, 12, pp.369–383. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0 84864246179&partnerID=tZOtx3y1 [Accessed February 21, 2014].

Emmitt, S., Sander, D. & Christoffersen, A.K., 2005. The Value Universe: Defining a Value Based Approach to Lean Construction. *13th Annual Conference of the International Group for Lean Construction*, pp.57–64. Available at: http://www.iglc.net/Papers/Details/349 [Accessed June 12, 2015].

Emmitt, S., Sander, D. & K., C.A., 2004. Implementing Value Through Lean Design Management. In *In Proceedings of the 12th International Conference*. pp. 361–374.

Esin, T. & Cosgun, N., 2007. A Study Conducted to Reduce Construction Waste Generation in Turkey. *Building and Environment*, 42(4), pp.1667–1674. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0360132306000473 [Accessed August 7, 2014].

Fellows, R. & Liu, A., 2008. *Research Methods for Construction*, Blackwell Publishing Ltd.

FMI & CMAA, 2005. *Sixth Annual Survey of Owners*, Formoso, C.T. et al., 2002. Material Waste in Building Industry : Main Causes and Prevention. *Journal of Construction Engineering and Management*, 128(4), pp.316–326.

Freire, J. & Alarcón, L.F., 2002. Achieving Lean Design Process: Improvement Methodology. *Journal of Construction Engineering and Management*, 128, pp.248–256.

Gamage, I.S.W., Osmani, M. & Glass, J., 2009. An Investıgation Into The Impact Of Procurement Systems On Waste Generation : The Contractors' Perspective. In *Proceedings 25th Annual ARCOM Conference*. Nottingham, UK, pp. 1031–1040.

Garrett, D.F. & Lee, J., 2010. Lean Construction Submittal Process - A Case Study. *Quality Engineering*, 23(1), pp.84–93.

George, J. & Jones, G.R., 2008. *Understanding and managing organizational behavior* Pearson In.,

Glaser, B.G. & Strauss, A.L., 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Available at: http://www.amazon.com/dp/0202302601 [Accessed June 12, 2015]

Harris, F. & McCaffer, R., 1997. *Modern Construction Management* Blackwell, London.

Hillson, D.A. & Hulett, D.T., 2004. Assessing risk probability: alternative approaches. In *2004 PMI Global Congress*. pp. 1–7.

Howell, G.A., 1999. WHAT IS LEAN CONSTRUCTION - 1999. In *IGLC - 7*. Berkeley, USA, pp. 1–10.

Imai, M., 1986. *Kaizen: The Key to Japan's Competitive Success*,

Issa, U.H., 2013. Implementation of lean construction techniques for minimizing the risks effect on project construction time. *Alexandria Engineering Journal*, 52(4), pp.697–704. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1110016813000641 [Accessed July 15, 2014].

Jørgensen, B. & Emmitt, S., 2009. Investigating the integration of design and construction from a "lean" perspective. *Construction Innovation: Information, Process, Management*, 9, pp.225–240.

Josephson, P.E. & Hammarlund, Y., 1999. Causes and costs of defects in construction a study of seven building projects. *Automation in construction*, 8, pp.681–687.

Kofoworola, O.F. & Gheewala, S.H., 2009. Estimation of construction waste generation and management in Thailand. *Waste management (New York, N.Y.)*, 29(2), pp.731–8. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18774703 [Accessed August 15, 2014].

Koskela, L., 2000. *An exploration towards a production theory and its application to construction*.

Koskela, L., 1992. *Application of the new production philosophy to construction*,

Koskela, L., 2001. On new footnotes to Shingo. In *Proceedings of 9th International Group for Lean Construction Conference.* pp. 11–22.

Koskela, L., Huovila, P. & Leinonen, J., 2002. Design Management in Building Construction: from theory to practice. *Journal of Construction Research*, 3(1), pp.1–16.

Lee, S. et al., 1999. Identifying Waste : Applications Of Construction Process Analysis. In *Seventh Conference of the International Group for Lean Construction*. Berkeley, USA, pp. 63–72.

Liker, J., 2004. *The Toyota Way*,

Lu, W. & Yuan, H., 2011. A framework for understanding waste management studies in construction. *Waste management (New York, N.Y.)*, 31(6), pp.1252–60. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21330125 [Accessed August 15, 2014].

Marhani, M.A., Jaapar, A. & Bari, N.A.A., 2012. Lean Construction: Towards Enhancing Sustainable Construction in Malaysia. *Procedia - Social and Behavioral Sciences*, 68, pp.87–98. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1877042812056923 [Accessed July 9, 2014].

Miletsky, R.J., 2010. Can "Lean Construction" Improve Your Bottom Line? (Cover Story). In *Associated General Contractors of America (AGC) Lean Construction Forum*. pp. 1–7. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=48414328&site=ehost-live [Accessed June 12, 2015].

Miller, J. & Glassner, B., 1997. The "inside" and the "outside": finding realities in interviews. In D. Silvermann, ed. *Qualitative Research: Theory, Method and Practice*. Sage, London, pp. 99–112.

Nicholson, M.P. & Naamani, Z., 1992. Managing Architectural Design. *Construction Management and Economics*, 10, pp.479–487.

Ohno, T., 1988. *Toyota Production System*, Available at: http://books.google.com/books?id=7_-67SshOy8C [Accessed June 12, 2015].

Ordoñez, I. & Rahe, U., 2013. Collaboration between design and waste management: Can it help close the material loop? *Resources, Conservation and Recycling*, 72, pp.108–117. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0921344913000037 [Accessed August 15, 2014].

Osmani, M., 2012. Construction Waste Minimization in the UK: Current Pressures for Change and Approaches. *Procedia - Social and Behavioral Sciences*, 40, pp.37–40. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1877042812006258 [Accessed August 15, 2014].

Osmani, M., Glass, J. & Price, a. D.F., 2008. Architects' Perspectives On Construction Waste Reduction by Design. *Waste Management*, 28(7), pp.1147–1158. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17624757 [Accessed August 9, 2014].

Pasquire, C. & Salvatierra-Garrido, J., 2011. Introducing the Concept of First and Last Value to Aid Lean Design: Learning from Social Housing Projects in Chile. *Architectural Engineering and Design Management*, 7, pp.128–138.

Patton, M., 1990. *Qualitative Evaluation and Research Methods*, Available at: http://legacy.oise.utoronto.ca/research/field-centres/ross/ctl1014/Patton1990.pdf [Accessed June 12, 2015].

PESHKIN, A., 1993. The Goodness of Qualitative Research. *Educational Researcher*, 22, pp.23–29.

Polat, G. & Ballard, G., 2004. Waste in Turkish Construction: Need for Lean Construction Techniques. In *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*. pp. 3–5.

Projects, D., 2006. *Best Practice Guidelines on the Preparation of Waste Management Plans for Construction Contents :*,

RIBA. (2013) *RIBA Plan of Work.* Available at: http://www.ribaplanofwork.com/PlanOfWork.aspx. [Accessed June 10, 2015]

Rischmoller, L., Alarcón, L.F. & Koskela, L., 2006. Improving Value Generation in the Design Process of Industrial Projects Using CAVT. *Journal of Management and Engineering*, (April), pp.52–60.

Roche, D. & Hegarty, S., 2006. *Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects*, Rogers, E.M. & Kincaid, D.L., 1981. *Communication Networks: Toward a New Paradigm for Research*, Available at: http://scholar.google.es/scholar?hl=es&q=Rogers+and+Kincaid+1981&btnG=&lr=#0 [Accessed June 12, 2015].

Sacks, R. et al., 2009. Analysis Framework for The Interaction Between Lean Construction and Building Information Modelling. In *Proceedings of the 17th Annual Conference of the International Group for Lean Construction (IGLC-17), Taipei, Taiwan, 15-17 July 2009*. pp. 221–233.

Sacks, R., Eastman, C.M. & Lee, G., 2004. Parametric 3D modeling in building construction with examples from precast concrete. *Automation in Construction*, 13, pp.291–312.

Salem, O. et al., 2006. Lean Construction: From Theory to Implementation. *Journal of Management in Engineering*, 22, pp.168–175.

Seppanen, O., Ballard, G. & Pesonen, S., 2010. The Combination of Last Planner System and Location-Based Management System. *Lean Construction Journal*, pp.43–54.

Serpell, A. & Alarcón, L.F., 1998. Construction process improvement methodology for construction projects. *International Journal of Project Management*, 16(4), pp.215–221.

Shingo, S., 1989. *A Study of the Toyota Production System*, New York: Productivity Press.

Skoyles, E.R., 1976. Materials wastage – a misuse of resources. *Batiment International, Building Research and Practice*, 4, pp.232–232.

Small, H.M. & Yasin, M.M., 2011. Assessing the implementation and effectiveness of process management initiatives at technologically consistent firms. *Business Process Management*, pp.6–20.

Stern, P.N., 1980. Grounded theory methodology: its uses and processes. *Image*, 12, pp.20–23.

Strauss, A.L. & Corbin, J.M., 1998. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*,

Summers, D.C., 2005. *Quality Management, Creating and Sustaining Organizational Effectiveness*, Upper Saddle River, New Jersey: PEARSON Prentice Hall.

Teo, M.M.M. & Loosemore, M., 2001. A Theory of Waste Behaviour in the Construction Industry. *Construction Management and Economics*, 19(7), pp.741–751. Available at: http://www.tandfonline.com/doi/abs/10.1080/01446190110067037 [Accessed August 2, 2014].

Tesch, R., 1991. Software for qualitative researchers, analysis needs and program capabilities. In *Using Computers in Qualitative Research*.

Thyssen, M.H., 2011. *Facilitating Value Creation and Delivery in Construction Projects, New Vistas for Design Management*. DTU.

Tribelsky, E. & Sacks, R., 2011. An Empirical Study of Information Flows in Multidisciplinary Civil Engineering Design Teams using Lean Measures. *Architectural Engineering and Design Management*, 7, pp.85–101.

Whelton, M.G., 2004. *The Development of Purpose in the Project Definition Phase of Construction Projects - Implications for Project Management*. University of California.

Womack, J., 1999. Manufacturing has moved to lean - it’s time construction does too. In *10th Winter Conference in Archistruction*. Neenan, Denver, Colorado, USA.

Womack, J.P. & Jones, D.T., 1996. *Lean Thinking*,

Wright, P., 2000. Strategic orientations, competitive advantage, and business performance. *Journal of Business Research*, 33(2), pp.143–151.

Yoders, J., 2009. BIM + Lean Construction: Powerful Combination. *Building Design & Construction*.

Yuan, H., 2013. A SWOT Analysis of Successful Construction Waste Management. *Journal of Cleaner Production*, 39, pp.1–8. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0959652612004234 [Accessed July 14, 2014].

Zhang, X., Wu, Y. & Shen, L., 2012. Application of Low Waste Technologies for Design and Construction: A Case Study in Hong Kong. *Renewable and Sustainable Energy Reviews*, 16(5), pp.2973–2979. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1364032112001141 [Accessed August 15, 2014].

APPENDIX A

PROFESSIONAL INFORMATION of INTERVIEW RESPONDENTS

Table A.1: Professional Information of Respondent A

Position of Respondent:			Owner / Designer
Company's Years of Experience:			30 (est. 1985)
Respondent's Years of Experience:			30 (from 1985)
Project Types That Company Works On;			
	Residential	✓	
	Office	✓	
	Cultural	✓	
	Health		
	Educational	✓	
	Industrial		
	Commercial	✓	
	Sports	✓	
	Transportation		
	Tourism	✓	
	Religional		
	Infrastructure		
	Urban Planning	✓	
	Landscape	✓	
Average Amount of Work Annually Completed in Company (m^2) :			200.000
Number of Employees Work in Company:			20-25

Table A.2: Professional Information of Respondent B

Position of Respondent:			Design Group Manager
Company's Years of Experience:			46 (est. 1969)
Respondent's Years of Experience:			32 (from 1983)
Project Types That Company Works On;			
	Residential	✓	
	Office	✓	
	Cultural	✓	
	Health		
	Educational		
	Industrial		
	Commercial	✓	
	Sports	✓	
	Transportation		
	Tourism	✓	
	Religional		
	Infrastructure	✓	
	Urban Planning		
	Landscape		
Average Amount of Work Annually Completed in Company (m^2) :			220.000
Number of Employees Work in Company:			30+

Table A.3: Professional Information of Respondent C

Position of Respondent:			Owner / Designer
Company's Years of Experience:			31 (est. 1984)
Respondent's Years of Experience:			31 (from 1984)
Project Types That Company Works On;			
	Residential	✓	
	Office	✓	
	Cultural	✓	
	Health	✓	
	Educational	✓	
	Industrial		
	Commercial	✓	
	Sports		
	Transportation	✓	
	Tourism	✓	
	Religional	✓	
	Infrastructure		
	Urban Planning		
	Landscape	✓	
Average Amount of Work Annually Completed in Company (m^2) :			200.000
Number of Employees Work in Company:			30+

Table A.4: Professional Information of Respondent D

Position of Respondent:			Owner / Designer
Company's Years of Experience:			24 (est. 1991)
Respondent's Years of Experience:			24 (from 1991)
Project Types That Company Works On;			
	Residential	✓	
	Office	✓	
	Cultural	✓	
	Health	✓	
	Educational	✓	
	Industrial		
	Commercial	✓	
	Sports		
	Transportation		
	Tourism	✓	
	Religional	✓	
	Infrastructure		
	Urban Planning	✓	
	Landscape		
Average Amount of Work Annually Completed in Company (m^2) :			230.000
Number of Employees Work in Company:			15-20

Table A.5: Professional Information of Respondent E

Position of Respondent:			Owner / Designer
Company's Years of Experience:			23 (est. 1992)
Respondent's Years of Experience:			28 (from 1987)
Project Types That Company Works On;			
	Residential	✓	
	Office	✓	
	Cultural	✓	
	Health		
	Educational	✓	
	Industrial		
	Commercial	✓	
	Sports		
	Transportation	✓	
	Tourism	✓	
	Religional	✓	
	Infrastructure		
	Urban Planning	✓	
	Landscape	✓	
Average Amount of Work Annually Completed in Company (m^2) :			N.A
Number of Employees Work in Company:			15-20

Table A.6: Professional Information of Respondent F

Position of Respondent:		Partner / Designer
Company's Years of Experience:		13 (est. 2002)
Respondent's Years of Experience:		14 (from 2001)
Project Types That Company Works On;		
Residential	✓	
Office	✓	
Cultural	✓	
Health		
Educational	✓	
Industrial	✓	
Commercial		
Sports		
Transportation		
Tourism	✓	
Religional		
Infrastructure	✓	
Urban Planning	✓	
Landscape	✓	
Average Amount of Work Annually Completed in Company (m^2) :		450.000
Number of Employees Work in Company:		10-15

Table A.7: Professional Information of Respondent G

Position of Respondent:			Partner / Designer
Company's Years of Experience:			18 (est. 1997)
Respondent's Years of Experience:			28 (from 1987)
Project Types That Company Works On;			
	Residential	✓	
	Office	✓	
	Cultural	✓	
	Health		
	Educational	✓	
	Industrial	✓	
	Commercial	✓	
	Sports	✓	
	Transportation		
	Tourism	✓	
	Religional	✓	
	Infrastructure		
	Urban Planning		
	Landscape		
Average Amount of Work Annually Completed in Company (m^2) :			250.000
Number of Employees Work in Company:			30+

Table A.8: Professional Information of Respondent H

Position of Respondent:		Partner / Designer
Company's Years of Experience:		42 (est. 1973)
Respondent's Years of Experience:		45 (from 1970)
Project Types That Company Works On;		
Residential	✓	
Office	✓	
Cultural	✓	
Health	✓	
Educational	✓	
Industrial	✓	
Commercial	✓	
Sports	✓	
Transportation	✓	
Tourism	✓	
Religional	✓	
Infrastructure		
Urban Planning	✓	
Landscape	✓	
Average Amount of Work Annually Completed in Company (m^2) :		N.A
Number of Employees Work in Company:		5-10

APPENDIX B

FREQUENCY & IMPACT EVALUATION QUESTIONNAIRE

This questionnaire was generated to provide data for thesis study named as “Lean Design Management – An Evaluation of Waste Items in Architectural Design Process” which is being conducted by S. Kaan Mazlum in Middle East Technical University – Building Sciences Graduate Program. Main goal of the study is to determine actual problems and inefficiencies of architectural design practice and evaluate negative effects of such problems over the project development phase. By this means, it is aimed to make contribution for an adaptation of “lean design framework” for the industry.

First phase of the research was completed by determining waste items of design process via the interviews conducted with Architects having at least 10 years experiences in managerial positions of a design organization. With your participation, you will contribute for the frequency and impact evaluation of lean design waste items. Within the contex of this questionnaire, you are expected to evaluate;

- **Frequency of occurrence;**
- **Impact over project cost;**
- **Impact over project duration, and**
- **Impact over project quality**

Parameters for each waste item. There are 34 questions in this questionnaire.

Thank you for your time and contribution.

Salih Kaan MAZLUM

Advisor: Inst. Dr. Mehmet Koray PEKERİÇLİ

A. PROFESSIONAL INFORMATION

There are 6 questions in this section about your professional background. Please mark appropriate choice or choices.

1. **Number of years that you are working in project environment:**

   ☐ **0-2** ☐ **3-5** ☐ **6-10** ☐ **11-20** ☐ **20+**

2. **Number of years that your organization is performing in project environment:**

   ☐ **0-2** ☐ **3-5** ☐ **6-10** ☐ **11-20** ☐ **20+**

3. **Job position that you are working at the present:**

   ☐ **Owner**
   ☐ **Manager**
   ☐ **Coordinator**
   ☐ **Designer**
   ☐ **Field Architect**
   ☐ **Consultant**
   ☐ **Controller**
   ☐ **Purchasing Architect**
   ☐ **Other (please specify)**

4. **Average amount of project that your organization finishes annually (thousands m^2):**

   ☐ **0-20** ☐ **20-50** ☐ **50-100** ☐ **100-200** ☐ **200+**

5. **Total number of personnel working in your organization:**

   ☐ **0-5** ☐ **6-10** ☐ **11-20** ☐ **21-30** ☐ **30+**

6. **Types of projects that you are involved in design process:**

   ☐ **Residential** ☐ **Commercial**
   ☐ **Office** ☐ **Religious**
   ☐ **Health** ☐ **Infrastructure**
   ☐ **Touristic** ☐ **Master Plan**
   ☐ **Education** ☐ **Mixed Use**
   ☐ **Industrial** ☐ **Other (please specify)**

B. WASTE ITEMS EVALUATION

There are **28 waste items** belonging to architectural design process listed in this section. Under each waste item there are **explanatory examples & sources** are given. Please mark appropriate available choice (*very low, low, high, very high*) for all waste items to evaluate their;

- **frequency of occurrence;**
- **impact over project cost;**
- **impact over project duration, and**
- **impact over project quality**

7. **Waiting for information from other disciplines**
   - ***ineffective controlling & monitoring of process***
   - ***the desire of client to work with a particular engineering team***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

8. **Ineffective use of qualified source**
   - ***ill-planned institutional spending for software, hardware etc. sources***
   - ***unawareness of the qualifications held***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

9. **Late information from client**
    - ***delayed decisions of client***
    - ***ineffective direction of client***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

10. **Architectural decision alterations**
    - ***insufficient architectural feasibility studies***
    - ***not following innovations in the industry***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

11. **Waiting for stationery, print and model works**
    - ***waiting for unpredicted technical problems***
    - ***ill-planned process organization***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

12. **Discontinuation in the project**
    - ***unpredicted alterations in regulation, zoning status etc.***
    - ***financial problems of client***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

13. High expectations from unqualified sources

- ***insufficient software, hardware etc. source support***
- ***unwillingness to allocate sources for new attitudes***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

14. Protracted previous works

- ***phase waiting for lacking information***
- ***ill-planned process organization***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

15. Relationship problems with public administrations

- ***problems about public funds in public projects***
- ***frequent personnel changes in especially local administrations***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

16. Rework

- ***passing next phase before making all required decisions***
- ***insufficient data exchange between stakeholders***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

17. Works/actions performed for providing site information

- ***diversity of data provider organizations***
- ***unpredictable working style of certification authorities***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

18. Undelivered production

- ***the change of client needs***
- ***ineffective feasibility studies***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

19. Works finished earlier than required

- ***production of further detailed drawings for the phase requirements***
- ***ineffective controlling & monitoring of process***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

20. Low speed working

- ***excessive number of stakeholders in the process***
- ***lack of in-house education***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

21. Unqualified data from other disciplines

- ***insufficient information sharing between stakeholders***
- ***not following the innovations on the industry***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

22. Ineffective employee performance

- ***inability to provide employee continuity***
- ***lack of in-house education***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

23. Incapability to have institutional habits

- ***inability to provide employee continuity***
- ***insufficient authority sharing, lack of clear job definition***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

24. Problems with client relations

- ***clients' rashness to start construction***
- ***discrepancy of "value" concept for client and designers***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

25. Explanation requirements (unfinished works)

- ***architects' lack of knowledge about site applications***
- ***positive attitude towards "correction in-situ"***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

26. Ineffective – unnecessary information exchange

- ***ill-planned design process***
- ***ineffective controlling & monitoring of process***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

27. Works/actions performed for providing presentation – design materials

- ***ill-planning of providing print & model etc. materials***
- ***unsuccessful management of documents and consumable materials***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

28. Inefficient meeting organizations

- ***frequently organized meetings with excessive number of participant***
- ***lacking participation of relevant and necessary professionals***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

29. Production of defective technical drawings & details etc.

- ***insufficient time allocated for design process***
- ***lack of self-evaluation of the organization***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

30. Revision works according to data provided from other disciplines

- ***inability of co-operation between disciplines from commencement of the project***
- ***jumping to next phase before necessary information reached from other disciplines***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

31. Concordance to regulations

- ***not producing regulatory complied drawings in first time***
- ***unexpected changes in regulation, zoning status, etc.***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

32. Unused employee creativity

- ***not expecting employees to make philosophical contribution & take responsibility***
- ***unawareness about the qualifications of personnel***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

33. Works/actions performed for providing reference technical information

- ***irregular structured form of blocks & library***
- ***insufficient institutional library***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

34. Unnecessary transportation processes

- ***inability to 100% digital submission of projects***
- ***requirement of sheets with signs of all disciplines together***

	very low	low	high	very high
probability of occurrence	☐	☐	☐	☐
impact over project cost	☐	☐	☐	☐
impact over project duration	☐	☐	☐	☐
impact over project quality	☐	☐	☐	☐

APPENDIX C

ONE WAY ANOVA RESULTS

C.1 Seek for statistically significant difference of the answers according to the experience level of the respondents

Hypothesis C.1.1:
Null Hypothesis: There is no significant difference between the population means of the *frequency of occurrence* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.
Where μ_i (i=1,2,3,4,5) refers to the population mean of *frequency* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	2,637897	,3400129	,0566688	2,522853	2,752941	1,9643	3,4643
3-5	27	2,687831	,3847302	,0740414	2,535636	2,840025	1,9286	3,3214
6-10	34	2,661765	,3570601	,0612353	2,537181	2,786349	2,1071	3,5000
11-20	27	2,439153	,3770307	,0725596	2,290005	2,588302	1,6786	3,3214
20+	27	2,510582	,4089864	,0787095	2,348792	2,672372	1,8214	3,3571
Total	151	2,593898	,3781133	,0307704	2,533098	2,654697	1,6786	3,5000

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,298	4	,325	2,352	**,057**
Within Groups	20,147	146	,138		
Total	21,445	150			

ANOVA test result gives a p-value of 0,057. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *frequency of occurrence* scores of respondents having different experience level".

Hypothesis C.1.2:

Null Hypothesis: There is no significant difference between the population means of the *impact over cost* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over cost* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	2,499008	,3474696	,0579116	2,381441	2,616575	1,6429	3,2857
3-5	27	2,539683	,4753885	,0914886	2,351625	2,727740	1,3929	3,2500
6-10	34	2,684874	,4222542	,0724160	2,537543	2,832205	1,7857	3,6786
11-20	27	2,440476	,5077886	,0977240	2,239602	2,641351	1,3571	3,6429
20+	27	2,617725	,5012558	,0964667	2,419435	2,816015	1,4286	3,6071
Total	151	2,558893	,4499849	,0366192	2,486537	2,631249	1,3571	3,6786

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,151	4	,288	1,437	**,225**
Within Groups	29,222	146	,200		
Total	30,373	150			

ANOVA test result gives a p-value of 0,225. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over cost* scores of respondents having different experience level".

Hypothesis C.1.3:

Null Hypothesis: There is no significant difference between the population means of the *impact over duration* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over duration* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	2,750992	,3737453	,0622909	2,624535	2,877449	1,9286	3,3214
3-5	27	2,797619	,3824803	,0736084	2,646315	2,948923	1,7857	3,3214
6-10	34	3,003151	,3833832	,0657497	2,869383	3,136920	2,3214	3,9286
11-20	27	2,751323	,4898380	,0942694	2,557549	2,945096	1,7857	3,7500
20+	27	2,824074	,5413555	,1041839	2,609921	3,038227	1,4643	3,7143
Total	151	2,829234	,4384941	,0356841	2,758725	2,899742	1,4643	3,9286

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,440	4	,360	1,919	**,110**
Within Groups	27,401	146	,188		
Total	28,842	150			

ANOVA test result gives a p-value of 0,110. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over duration* scores of respondents having different experience level".

Hypothesis C.1.4:

Null Hypothesis: There is no significant difference between the population means of the *impact over quality* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over quality* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	2,606151	,4451296	,0741883	2,455541	2,756761	1,6071	3,3214
3-5	27	2,617725	,4487921	,0863701	2,440189	2,795261	1,4643	3,3214
6-10	34	2,787815	,4432847	,0760227	2,633146	2,942484	1,9643	3,6429
11-20	27	2,534392	,4309095	,0829286	2,363929	2,704854	1,6429	3,2143
20+	27	2,664021	,5748745	,1106347	2,436608	2,891434	1,3929	3,7143
Total	151	2,646641	,4703478	,0382764	2,571011	2,722272	1,3929	3,7143

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,108	4	,277	1,260	**,288**
Within Groups	32,076	146	,220		
Total	33,184	150			

ANOVA test result gives a p-value of 0,288. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over quality* scores of respondents having different experience level".

Hypothesis C.1.5:

Null Hypothesis: There is no significant difference between the population means of the *cost risk factor* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *cost risk factor* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	6,667907	1,6308760	,2718127	6,116098	7,219716	3,4375	10,7959
3-5	27	6,958900	2,0796899	,4002365	6,136202	7,781598	3,0166	10,4388
6-10	34	7,235519	1,9520766	,3347784	6,554407	7,916631	4,2730	12,8750
11-20	27	6,071098	1,9530779	,3758700	5,298486	6,843710	2,2781	10,5383
20+	27	6,720899	2,1992304	,4232421	5,850913	7,590886	2,6020	11,9898
Total	151	6,750507	1,9632058	,1597634	6,434829	7,066184	2,2781	12,8750

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21,903	4	5,476	1,437	**,225**
Within Groups	556,224	146	3,810		
Total	578,127	150			

ANOVA test result gives a p-value of 0,225. Since this p-value is greater than $\alpha=0,05$ significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *cost risk factor* scores of respondents having different experience level".

Hypothesis C.1.6:

Null Hypothesis: There is no significant difference between the population means of the *duration risk factor* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *duration risk factor* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	7,335884	1,7594516	,2932419	6,740572	7,931197	4,0689	11,1352
3-5	27	7,636054	1,9454952	,3744107	6,866442	8,405667	3,5077	10,7946
6-10	34	8,083021	1,9839286	,3402410	7,390795	8,775246	5,1926	13,7500
11-20	27	6,834703	2,1232180	,4086135	5,994786	7,674620	3,5816	11,7436
20+	27	7,241591	2,3044146	,4434848	6,329995	8,153187	2,6671	12,4694
Total	151	7,451311	2,0303438	,1652270	7,124838	7,777784	2,6671	13,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	26,422	4	6,606	1,629	**,170**
Within Groups	591,922	146	4,054		
Total	618,344	150			

ANOVA test result gives a p-value of 0,170. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *duration risk factor* scores of respondents having different experience level".

Hypothesis C.1.7:

Null Hypothesis: There is no significant difference between the population means of the *quality risk factor* scores of respondents having different experience level.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *quality risk factor* scores for each range for experience level of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	36	6,986855	1,9216913	,3202819	6,336648	7,637062	3,2270	11,0115
3-5	27	7,161423	2,0339311	,3914302	6,356827	7,966019	3,1569	10,7946
6-10	34	7,522847	2,0361231	,3491922	6,812410	8,233284	4,5906	12,7500
11-20	27	6,289635	1,8660387	,3591193	5,551455	7,027816	3,4439	10,2015
20+	27	6,851190	2,3956120	,4610357	5,903518	7,798863	2,5370	12,4694
Total	151	6,989830	2,0616826	,1677773	6,658318	7,321342	2,5370	12,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24,211	4	6,053	1,441	**,223**
Within Groups	613,369	146	4,201		
Total	637,580	150			

ANOVA test result gives a p-value of 0,223. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *quality risk factor* scores of respondents having different experience level".

C.2 Seek for statistically significant difference of the answers according to the experience level of the respondents' organizations

Hypothesis C.2.1:

Null Hypothesis: There is no significant difference between the population means of the *frequency of occurrence* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others
Where μ_i (i=1,2,3,4,5) refers to the population mean of *frequency* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	2,433036	,3718588	,1314719	2,122154	2,743917	2,0000	3,1786
3-5	19	2,806391	,4110705	,0943061	2,608261	3,004521	1,9643	3,5000
6-10	30	2,623810	,3181598	,0580878	2,505007	2,742612	2,1071	3,4643
11-20	35	2,555102	,3958388	,0669090	2,419127	2,691077	1,6786	3,3214
20+	59	2,555085	,3699860	,0481681	2,458666	2,651504	1,8214	3,3571
Total	151	2,593898	,3781133	,0307704	2,533098	2,654697	1,6786	3,5000

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,233	4	,308	2,227	**,069**
Within Groups	20,212	146	,138		
Total	21,445	150			

ANOVA test result gives a p-value of 0,069. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is “no significant difference between the population means of the *frequency of occurrence* scores according to the experience level of the respondents' organizations”.

Hypothesis C.2.2:

Null Hypothesis: There is no significant difference between the population means of the *impact over cost* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over cost* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	2,352679	,2941593	,1040010	2,106755	2,598602	2,1071	2,9286
3-5	19	2,751880	,5676304	,1302234	2,478291	3,025469	1,3929	3,6786
6-10	30	2,539286	,3513508	,0641476	2,408089	2,670482	1,6429	3,1786
11-20	35	2,518367	,4355499	,0736214	2,368751	2,667984	1,3571	3,2143
20+	59	2,558717	,4701581	,0612094	2,436193	2,681241	1,4286	3,6071
Total	151	2,558893	,4499849	,0366192	2,486537	2,631249	1,3571	3,6786

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,117	4	,279	1,393	**,239**
Within Groups	29,256	146	,200		
Total	30,373	150			

ANOVA test result gives a p-value of 0,239. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over cost* "scores according to the experience level of the respondents' organizations".

Hypothesis C.2.3:

Null Hypothesis: There is no significant difference between the population means of the *impact over duration* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over duration* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	2,741071	,3850097	,1361215	2,419195	3,062948	2,1429	3,3214
3-5	19	3,028195	,5228046	,1199396	2,776212	3,280179	2,0714	3,9286
6-10	30	2,801190	,3287592	,0600229	2,678430	2,923951	1,9286	3,5357
11-20	35	2,829592	,4134305	,0698825	2,687573	2,971610	1,7857	3,7143
20+	59	2,791162	,4737020	,0616708	2,667715	2,914610	1,4643	3,7143
Total	151	2,829234	,4384941	,0356841	2,758725	2,899742	1,4643	3,9286

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,923	4	,231	1,207	**,310**
Within Groups	27,918	146	,191		
Total	28,842	150			

ANOVA test result gives a p-value of 0,310. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over duration* scores according to the experience level of the respondents' organizations."

Hypothesis C.2.4:

Null Hypothesis: There is no significant difference between the population means of the *impact over quality* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over quality* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	2,607143	,3333941	,1178726	2,328418	2,885867	2,1071	3,1786
3-5	19	2,776316	,5954574	,1366073	2,489315	3,063317	1,4643	3,6429
6-10	30	2,585714	,4220147	,0770490	2,428131	2,743297	1,6071	3,3214
11-20	35	2,678571	,4485872	,0758251	2,524476	2,832667	1,6071	3,6071
20+	59	2,622276	,4825055	,0628169	2,496534	2,748018	1,3929	3,7143
Total	151	2,646641	,4703478	,0382764	2,571011	2,722272	1,3929	3,7143

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,514	4	,129	,574	**,682**
Within Groups	32,670	146	,224		
Total	33,184	150			

ANOVA test result gives a p-value of 0,682. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is “no significant difference between the population means of the *impact over quality* scores according to the experience level of the respondents' organizations”.

Hypothesis C.2.5:

Null Hypothesis: There is no difference between the population means of the *cost risk factor* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *cost risk factor* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	5,801499	1,6262078	,5749513	4,441955	7,161042	4,2857	9,3087
3-5	19	7,900175	2,5412679	,5830068	6,675323	9,125026	3,3329	12,8750
6-10	30	6,715221	1,5298993	,2793201	6,143947	7,286495	3,7551	10,1454
11-20	35	6,530722	1,8194775	,3075478	5,905709	7,155734	2,2781	10,5574
20+	59	6,657277	1,9843223	,2583368	6,140160	7,174394	2,6020	11,9898
Total	151	6,750507	1,9632058	,1597634	6,434829	7,066184	2,2781	12,8750

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34,559	4	8,640	2,321	**,060**
Within Groups	543,568	146	3,723		
Total	578,127	150			

ANOVA test result gives a p-value of 0,060. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is “no significant difference between the population means of the *cost risk factor* scores according to the experience level of the respondents' organizations”.

Hypothesis C.2.6:

Null Hypothesis: There is no difference between the population means of the *duration risk factor* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *duration risk factor* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	6,746014	1,8437329	,6518580	5,204615	8,287413	4,5918	10,5574
3-5	19	8,665212	2,5350347	,5815768	7,443365	9,887060	4,0689	13,7500
6-10	30	7,407313	1,6085753	,2936843	6,806661	8,007965	4,4082	11,7436
11-20	35	7,320372	1,9235846	,3251451	6,659597	7,981146	3,5077	11,1505
20+	59	7,256075	2,0474777	,2665589	6,722499	7,789650	2,6671	12,4694
Total	151	7,451311	2,0303438	,1652270	7,124838	7,777784	2,6671	13,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34,884	4	8,721	2,182	**,074**
Within Groups	583,460	146	3,996		
Total	618,344	150			

ANOVA test result gives a p-value of 0,074. Since this p-value is greater than $\alpha=0,05$ significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is “no significant difference between the population means of the *duration risk factor* scores according to the experience level of the respondents' organizations”.

Hypothesis C.2.7:

Null Hypothesis: There is no difference between the population means of the *quality risk factor* scores according to the experience level of the respondents' organizations.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *quality risk factor* scores for each range for experience level of organizations.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-2	8	6,421397	1,7470676	,6176817	4,960812	7,881982	4,5153	10,1033
3-5	19	7,983754	2,6105109	,5988923	6,725528	9,241980	3,2270	12,7500
6-10	30	6,853784	1,7191881	,3138794	6,211829	7,495739	3,6735	11,0115
11-20	35	6,970117	2,0427123	,3452814	6,268420	7,671813	3,1569	11,1122
20+	59	6,827698	2,0447185	,2661997	6,294841	7,360555	2,5370	12,4694
Total	151	6,989830	2,0616826	,1677773	6,658318	7,321342	2,5370	12,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23,475	4	5,869	1,395	**,238**
Within Groups	614,106	146	4,206		
Total	637,580	150			

ANOVA test result gives a p-value of 0,238. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *quality risk factor* scores according to the experience level of the respondents' organizations".

C.3. Seek for statistically significant difference of the answers according to job position of respondents

Hypothesis C.3.1:

Null Hypothesis: There is no significant difference between the population means of the *frequency of occurrence* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_9$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *frequency* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	2,571429	,4204589	,0755167	2,417203	2,725654	1,6786	3,3571
Manager	6	2,523810	,5074278	,2071565	1,991297	3,056322	1,8929	3,3214
Coordinator	14	2,377551	,2248819	,0601022	2,247708	2,507394	1,9643	2,7500
Designer	43	2,639535	,2856945	,0435680	2,551611	2,727459	2,1071	3,3571
Field Architect	34	2,588235	,4465247	,0765784	2,432435	2,744035	1,8214	3,5000
Consultant	6	2,714286	,4694765	,1916630	2,221600	3,206971	2,2500	3,4643
Controller	9	2,630952	,2868282	,0956094	2,410477	2,851428	2,1071	3,0000
Purchasing Architect	2	2,910714	,5808377	,4107143	-2,307906	8,129334	2,5000	3,3214
Other	6	2,708333	,4294139	,1753075	2,257691	3,158976	2,2143	3,3214
Total	151	2,593898	,3781133	,0307704	2,533098	2,654697	1,6786	3,5000

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,170	8	,146	1,024	**,421**
Within Groups	20,276	142	,143		
Total	21,445	150			

ANOVA test result gives a p-value of 0,421. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *frequency of occurrence* scores according to job position of respondents".

Hypothesis C.3.2:

Null Hypothesis: There is no significant difference between the population means of the *impact over cost* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_9$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *impact over cost* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	2,633641	,5083460	,0913016	2,447178	2,820103	1,3571	3,5714
Manager	6	2,732143	,4633232	,1891509	2,245915	3,218371	1,8929	3,1786
Coordinator	14	2,464286	,2657887	,0710350	2,310824	2,617748	1,8214	3,0000
Designer	43	2,611296	,3777402	,0576048	2,495044	2,727547	1,7857	3,6429
Field Architect	34	2,409664	,5321480	,0912626	2,223989	2,595339	1,4286	3,6786
Consultant	6	2,577381	,2539652	,1036808	2,310861	2,843901	2,2857	2,9286
Controller	9	2,468254	,4298509	,1432836	2,137841	2,798667	1,6071	3,0000
Purchasing Architect	2	3,339286	,3788072	,2678571	-,064162	6,742733	3,0714	3,6071
Other	6	2,547619	,3736654	,1525483	2,155481	2,939757	2,0357	3,1429
Total	151	2,558893	,4499849	,0366192	2,486537	2,631249	1,3571	3,6786

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2,649	8	,331	1,696	**,104**
Within Groups	27,724	142	,195		
Total	30,373	150			

ANOVA test result gives a p-value of 0,104. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over cost* scores according to job position of respondents".

Hypothesis C.3.3:

Null Hypothesis: There is no significant difference between the population means of the *impact over duration* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_9$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *impact over duration* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	2,891705	,4140890	,0743726	2,739816	3,043594	2,0714	3,7143
Manager	6	2,839286	,5386823	,2199161	2,273973	3,404598	1,8571	3,3571
Coordinator	14	2,607143	,3476767	,0929205	2,406400	2,807885	1,7857	3,1429
Designer	43	2,914452	,3531356	,0538527	2,805773	3,023131	2,1429	3,7500
Field Architect	34	2,685924	,5680895	,0974265	2,487709	2,884140	1,4643	3,9286
Consultant	6	3,011905	,3340129	,1363602	2,661380	3,362430	2,4286	3,3214
Controller	9	2,710317	,2412000	,0804000	2,524915	2,895720	2,1429	2,9286
Purchasing Architect	2	3,571429	0E-7	0E-7	3,571429	3,571429	3,5714	3,5714
Other	6	2,964286	,2839230	,1159111	2,666327	3,262245	2,6071	3,3214
Total	151	2,829234	,4384941	,0356841	2,758725	2,899742	1,4643	3,9286

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3,361	8	,420	2,342	,022
Within Groups	25,480	142	,179		
Total	28,842	150			

ANOVA test result gives a p-value of 0,022. P-value is less than α=0,05 significance level. However, the post-hoc tests have not given any significant difference in between any two job positions. So the null hypothesis, H_0, was accepted and it was concluded that there is “no significant difference between the population means of the *impact over duration* scores according to job position of respondents".

Hypothesis C.3.4:

Null Hypothesis: There is no significant difference between the population means of the *impact over quality* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_9$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *impact over quality* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	2,730415	,4892413	,0878703	2,550960	2,909870	1,4643	3,7143
Manager	6	2,773810	,5261851	,2148142	2,221612	3,326007	1,8571	3,3214
Coordinator	14	2,369898	,3597725	,0961532	2,162172	2,577624	1,6429	3,0714
Designer	43	2,661130	,3863383	,0589160	2,542232	2,780027	1,5714	3,6071
Field Architect	34	2,571429	,5853948	,1003944	2,367175	2,775682	1,3929	3,6429
Consultant	6	2,630952	,4366306	,1782537	2,172737	3,089168	2,0357	3,1786
Controller	9	2,603175	,3404325	,1134775	2,341495	2,864854	1,9286	3,0000
Purchasing Architect	2	3,410714	,2272843	,1607143	1,368646	5,452783	3,2500	3,5714
Other	6	2,880952	,2542161	,1037833	2,614169	3,147736	2,5000	3,1429
Total	151	2,646641	,4703478	,0382764	2,571011	2,722272	1,3929	3,7143

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3,104	8	,388	1,831	**,076**
Within Groups	30,080	142	,212		
Total	33,184	150			

ANOVA test result gives a p-value of 0,076. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over quality* scores according to job position of respondents".

Hypothesis C.3.5:

Null Hypothesis: There is no significant difference between the population means of the *cost risk factor* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_9$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *cost risk factor* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	6,918491	2,2064036	,3962818	6,109175	7,727806	2,2781	11,9898
Manager	6	7,048044	2,3609272	,9638445	4,570403	9,525685	3,5829	10,5574
Coordinator	14	5,884840	1,0037725	,2682695	5,305279	6,464401	3,9681	7,3622
Designer	43	6,950136	1,5717623	,2396915	6,466419	7,433853	4,2730	10,7959
Field Architect	34	6,433899	2,4278258	,4163687	5,586790	7,281007	2,6020	12,8750
Consultant	6	7,056760	1,8036840	,7363509	5,163910	8,949610	5,7143	10,1454
Controller	9	6,574263	1,6602887	,5534296	5,298052	7,850474	3,3865	9,0000
Purchasing Architect	2	9,609694	,8369835	,5918367	2,089695	17,129693	9,0179	10,2015
Other	6	6,973427	1,9652765	,8023208	4,910996	9,035858	5,2194	10,4388
Total	151	6,750507	1,9632058	,1597634	6,434829	7,066184	2,2781	12,8750

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34,509	8	4,314	1,127	**,349**
Within Groups	543,617	142	3,828		
Total	578,127	150			

ANOVA test result gives a p-value of 0,349. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *cost risk factor* scores according to job position of respondents".

Hypothesis C.3.6:

Null Hypothesis: There is no significant difference between the population means of the *duration risk factor* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_9$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *duration risk factor* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	7,553448	2,1367640	,3837741	6,769677	8,337219	4,0765	12,4694
Manager	6	7,329294	2,5304480	1,0330511	4,673752	9,984837	3,5153	11,1505
Coordinator	14	6,225128	1,1634207	,3109373	5,553388	6,896867	3,8903	8,3061
Designer	43	7,758217	1,6226945	,2474586	7,258825	8,257608	4,5918	11,0306
Field Architect	34	7,149310	2,5610898	,4392233	6,255703	8,042916	2,6671	13,7500
Consultant	6	8,233418	2,0319405	,8295362	6,101028	10,365809	6,0714	11,1352
Controller	9	7,185516	1,3204232	,4401411	6,170549	8,200483	4,5153	8,7857
Purchasing Architect	2	10,395408	2,0744204	1,4668367	-8,242520	29,033336	8,9286	11,8622
Other	6	8,053784	1,6362827	,6680096	6,336611	9,770957	5,8520	10,4388
Total	151	7,451311	2,0303438	,1652270	7,124838	7,777784	2,6671	13,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52,432	8	6,554	1,645	**,117**
Within Groups	565,912	142	3,985		
Total	618,344	150			

ANOVA test result gives a p-value of 0,349. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *duration risk factor* scores according to job position of respondents".

Hypothesis C.3.7:

Null Hypothesis: There is no significant difference between the population means of the *quality risk factor* scores according to job position of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_9$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5,6,7,8,9) refers to the population mean of *quality risk factor* scores for each position.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Owner	31	7,143845	2,2176455	,3983009	6,330406	7,957284	3,5038	12,4694
Manager	6	7,179422	2,5581876	1,0443757	4,494769	9,864075	3,5153	11,0319
Coordinator	14	5,673743	1,1977303	,3201069	4,982194	6,365292	3,5791	7,3622
Designer	43	7,093172	1,6128271	,2459538	6,596817	7,589526	3,7041	10,6786
Field Architect	34	6,870573	2,5602692	,4390825	5,977253	7,763893	2,5370	12,7500
Consultant	6	7,284864	2,4420099	,9969464	4,722132	9,847596	5,0893	11,0115
Controller	9	6,917659	1,5004137	,5001379	5,764339	8,070979	4,0638	9,0000
Purchasing Architect	2	9,861607	1,3195118	,9330357	-1,993736	21,716950	8,9286	10,7946
Other	6	7,866497	1,7731316	,7238780	6,005709	9,727284	5,5357	10,4388
Total	151	6,989830	2,0616826	,1677773	6,658318	7,321342	2,5370	12,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	47,818	8	5,977	1,439	,185
Within Groups	589,763	142	4,153		
Total	637,580	150			

ANOVA test result gives a p-value of 0,185. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *quality risk factor* scores according to job position of respondents.

C.4. Seek for statistically significant difference of the answers according to the amount of projects that the organization of respondents finished annually

Hypothesis C.4.1:

Null Hypothesis: There is no significant difference between the population means of the *frequency of occurrence* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *frequency* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	2,617143	,3854166	,0770833	2,458051	2,776235	1,6786	3,2857
20-50	26	2,471154	,3296596	,0646516	2,338001	2,604306	1,9643	3,4643
50-100	30	2,569048	,3026003	,0552470	2,456055	2,682040	1,9286	3,2500
100-200	31	2,665899	,4271353	,0767158	2,509224	2,822573	1,8929	3,5000
200+	35	2,610204	,4064098	,0686958	2,470597	2,749811	1,8214	3,3571
Total	147	2,590136	,3757932	,0309949	2,528879	2,651393	1,6786	3,5000

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,592	4	,148	1,049	**,384**
Within Groups	20,027	142	,141		
Total	20,618	146			

ANOVA test result gives a p-value of 0,384. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *frequency of occurrence* scores according to the amount of projects that the organization of respondents finished annually".

Hypothesis C.4.2:

Null Hypothesis: There is no significant difference between the population means of the *impact over cost* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over cost* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	2,578571	,5183700	,1036740	2,364599	2,792544	1,3571	3,6429
20-50	26	2,506868	,4640130	,0910004	2,319449	2,694287	1,3929	3,3571
50-100	30	2,546429	,3644752	,0665438	2,410331	2,682526	1,6429	3,6071
100-200	31	2,540323	,4318074	,0775549	2,381934	2,698711	1,7857	3,6786
200+	35	2,586735	,5018188	,0848229	2,414354	2,759115	1,4286	3,5714
Total	147	2,553207	,4529777	,0373610	2,479369	2,627045	1,3571	3,6786

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,118	4	,029	,140	**,967**
Within Groups	29,840	142	,210		
Total	29,958	146			

ANOVA test result gives a p-value of 0,967. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over cost* scores according to the amount of projects that the organization of respondents finished annually."

Hypothesis C.4.3:

Null Hypothesis: There is no difference between the population means of the *impact over duration* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over duration* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	2,961429	,3995533	,0799107	2,796501	3,126356	2,3214	3,7500
20-50	26	2,820055	,3885453	,0762000	2,663118	2,976992	2,0714	3,6071
50-100	30	2,794048	,3280896	,0599007	2,671537	2,916558	1,8571	3,5714
100-200	31	2,817972	,4923181	,0884229	2,637389	2,998556	1,8571	3,9286
200+	35	2,756122	,5325175	,0900119	2,573196	2,939049	1,4643	3,7143
Total	147	2,823129	,4402822	,0363139	2,751361	2,894898	1,4643	3,9286

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,662	4	,165	,850	**,496**
Within Groups	27,640	142	,195		
Total	28,302	146			

ANOVA test result gives a p-value of 0,496. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no difference between the population means of the *impact over duration* scores according to the amount of projects that the organization of respondents finished annually."

Hypothesis C.4.4:

Null Hypothesis: There is no significant difference between the population means of the *impact over quality* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over quality* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	2,738571	,4454418	,0890884	2,554702	2,922441	1,5714	3,2857
20-50	26	2,605769	,5087480	,0997737	2,400281	2,811257	1,4643	3,6071
50-100	30	2,580952	,3598339	,0656964	2,446588	2,715317	1,7857	3,5714
100-200	31	2,648618	,4685788	,0841592	2,476741	2,820494	1,8571	3,6429
200+	35	2,652041	,5611164	,0948460	2,459291	2,844791	1,3929	3,7143
Total	147	2,643343	,4729913	,0390117	2,566243	2,720444	1,3929	3,7143

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,384	4	,096	,422	**,793**
Within Groups	32,280	142	,227		
Total	32,663	146			

ANOVA test result gives a p-value of 0,793. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over quality* scores according to the amount of projects that the organization of respondents finished annually".

Hypothesis C.4.5:

Null Hypothesis: There is no significant difference between the population means of the *cost risk factor* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *cost risk factor* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	6,851837	2,0330549	,4066110	6,012633	7,691041	2,2781	10,5612
20-50	26	6,277522	1,7522761	,3436496	5,569762	6,985281	3,3329	10,1454
50-100	30	6,608248	1,5210855	,2777109	6,040266	7,176231	3,1684	10,0982
100-200	31	6,901251	2,1600420	,3879550	6,108941	7,693561	3,5829	12,8750
200+	35	6,916071	2,2380766	,3783040	6,147265	7,684878	2,6020	11,9898
Total	147	6,726260	1,9612608	,1617621	6,406562	7,045958	2,2781	12,8750

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8,258	4	2,064	,530	**,714**
Within Groups	553,338	142	3,897		
Total	561,595	146			

ANOVA test result gives a p-value of 0,714. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *cost risk factor* scores according to the amount of projects that the organization of respondents finished annually".

Hypothesis C.4.6:

Null Hypothesis: There is no significant difference between the population means of the *duration risk factor* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *duration risk factor* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	7,843724	1,9759706	,3951941	7,028084	8,659365	4,0765	10,8482
20-50	26	7,042190	1,6949268	,3324025	6,357594	7,726786	4,0689	11,1352
50-100	30	7,232143	1,4578451	,2661649	6,687775	7,776511	3,5816	10,7946
100-200	31	7,674004	2,4414265	,4384931	6,778482	8,569527	3,5153	13,7500
200+	35	7,362682	2,3424062	,3959389	6,558038	8,167327	2,6671	12,4694
Total	147	7,426819	2,0337859	,1677438	7,095299	7,758338	2,6671	13,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11,367	4	2,842	,681	,606
Within Groups	592,531	142	4,173		
Total	603,898	146			

ANOVA test result gives a p-value of 0,606. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *duration risk factor* scores according to the amount of projects that the organization of respondents finished annually".

Hypothesis C.4.7:

Null Hypothesis: There is no significant difference between the population means of the *quality risk factor* scores according to the amount of projects that the organization of respondents finished annually.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *quality risk factor* scores for each range for amount of projects that the organization of respondents finished annually.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-20	25	7,258724	1,9411060	,3882212	6,457475	8,059974	3,7041	10,4439
20-50	26	6,524137	1,8798720	,3686732	5,764840	7,283433	3,2270	11,0115
50-100	30	6,691624	1,5201829	,2775462	6,123979	7,259270	3,4439	10,7946
100-200	31	7,227123	2,3110852	,4150831	6,379410	8,074836	3,5153	12,7500
200+	35	7,107945	2,4161710	,4084074	6,277961	7,937928	2,5370	12,4694
Total	147	6,970498	2,0554130	,1695276	6,635453	7,305544	2,5370	12,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12,293	4	3,073	,722	**,578**
Within Groups	604,517	142	4,257		
Total	616,809	146			

ANOVA test result gives a p-value of 0,578. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *quality risk factor* scores according to the amount of projects that the organization of respondents finished annually."

C.5. Seek for statistically significant difference of the answers according to total number of personnel working in the organization of respondents

Hypothesis C.5.1:

Null Hypothesis: There is no significant difference between the population means of the *frequency of occurrence* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *frequency* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	2,537500	,3436984	,0543435	2,427580	2,647420	1,6786	3,2857
6-10	26	2,681319	,3314968	,0650119	2,547424	2,815213	2,1071	3,3571
11-20	17	2,489496	,4095022	,0993189	2,278949	2,700042	1,9643	3,4643
21-30	8	2,683036	,3496341	,1236143	2,390734	2,975337	2,2143	3,2500
30+	59	2,619855	,4089711	,0532435	2,513276	2,726433	1,8214	3,5000
Total	150	2,597143	,3772644	,0308035	2,536275	2,658011	1,6786	3,5000

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,613	4	,153	1,079	**,369**
Within Groups	20,594	145	,142		
Total	21,207	149			

ANOVA test result gives a p-value of 0,369. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *frequency of occurrence* scores according to total number of personnel working in the organization of respondents".

Hypothesis C.5.2:

Null Hypothesis: There is no significant difference between the population means of the *impact over cost* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over cost* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	2,516964	,5050755	,0798594	2,355433	2,678495	1,3571	3,6429
6-10	26	2,700549	,3794568	,0744176	2,547284	2,853815	1,6429	3,5714
11-20	17	2,382353	,4292711	,1041135	2,161642	2,603064	1,5357	3,2857
21-30	8	2,589286	,3107641	,1098717	2,329480	2,849091	2,2500	3,1071
30+	59	2,564770	,4530409	,0589809	2,446707	2,682833	1,4286	3,6786
Total	150	2,556190	,4502611	,0367637	2,483545	2,628836	1,3571	3,6786

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,130	4	,283	1,409	**,234**
Within Groups	29,077	145	,201		
Total	30,208	149			

ANOVA test result gives a p-value of 0,234. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *impact over cost* scores according to total number of personnel working in the organization of respondents".

Hypothesis C.5.3:

Null Hypothesis: There is no significant difference between the population means of the *impact over duration* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over duration* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	2,842857	,4300037	,0679896	2,705335	2,980379	1,8571	3,7500
6-10	26	2,969780	,3863345	,0757664	2,813736	3,125824	1,9286	3,7143
11-20	17	2,661765	,4462710	,1082366	2,432313	2,891216	1,7857	3,3214
21-30	8	2,812500	,3135369	,1108520	2,550377	3,074623	2,3571	3,3214
30+	59	2,805690	,4727474	,0615465	2,682491	2,928889	1,4643	3,9286
Total	150	2,828095	,4397392	,0359046	2,757147	2,899043	1,4643	3,9286

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,033	4	,258	1,347	**,255**
Within Groups	27,780	145	,192		
Total	28,812	149			

ANOVA test result gives a p-value of 0,255. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is “no significant difference between the population means of the *impact over duration* scores according to total number of personnel working in the organization of respondents”.

Hypothesis C.5.4:

Null Hypothesis: There is no significant difference between the population means of the *impact over quality* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots . = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *impact over quality* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	2,659821	,4726278	,0747290	2,508668	2,810975	1,4643	3,5714
6-10	26	2,744505	,4505883	,0883676	2,562509	2,926502	1,6071	3,7143
11-20	17	2,422269	,5569075	,1350699	2,135934	2,708604	1,5714	3,3214
21-30	8	2,727679	,3398559	,1201572	2,443552	3,011805	2,3571	3,3214
30+	59	2,642857	,4616256	,0600985	2,522557	2,763157	1,3929	3,6429
Total	150	2,644524	,4712007	,0384734	2,568500	2,720548	1,3929	3,7143

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,165	4	,291	1,323	**,264**
Within Groups	31,918	145	,220		
Total	33,082	149			

ANOVA test result gives a p-value of 0,264. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is “no significant difference between the population means of the *impact over quality* scores according to total number of personnel working in the organization of respondents”.

Hypothesis C.5.5:

Null Hypothesis: There is no significant difference between the population means of the *cost risk factor* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *cost risk factor* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	6,486990	1,9075735	,3016139	5,876918	7,097061	2,2781	10,5612
6-10	26	7,319221	1,7611520	,3453903	6,607876	8,030566	3,7551	11,9898
11-20	17	6,059424	2,0091965	,4873017	5,026390	7,092457	3,0166	10,7959
21-30	8	6,994898	1,5730932	,5561724	5,679759	8,310037	5,2985	10,0982
30+	59	6,853079	2,1013100	,2735673	6,305474	7,400683	2,6020	12,8750
Total	150	6,753869	1,9693465	,1607965	6,436133	7,071605	2,2781	12,8750

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20,403	4	5,101	1,327	**,263**
Within Groups	557,468	145	3,845		
Total	577,871	149			

ANOVA test result gives a p-value of 0,264. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *cost risk factor* scores according to total number of personnel working in the organization of respondents".

Hypothesis C.5.6:

Null Hypothesis: There is no significant difference between the population means of the *duration risk factor* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots. = \mu_5$
H_A: At least one μ_i is different from the others.

Where μ_i (i=1,2,3,4,5) refers to the population mean of *duration risk factor* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	7,293335	1,8163114	,2871840	6,712451	7,874220	3,5153	10,8482
6-10	26	8,048420	1,8793867	,3685780	7,289320	8,807521	4,4082	12,4694
11-20	17	6,759979	2,1158734	,5131747	5,672097	7,847861	3,5077	11,1352
21-30	8	7,605708	1,6979643	,6003210	6,186174	9,025242	5,5561	10,7946
30+	59	7,492693	2,2345546	,2909142	6,910365	8,075021	2,6671	13,7500
Total	150	7,458844	2,0350275	,1661593	7,130511	7,787177	2,6671	13,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18,676	4	4,669	1,131	**,344**
Within Groups	598,383	145	4,127		
Total	617,059	149			

ANOVA test result gives a p-value of 0,344. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no significant difference between the population means of the *duration risk factor* scores according to total number of personnel working in the organization of respondents".

Hypothesis C.5.7:

Null Hypothesis: There is no difference between the population means of the *quality risk factor* scores according to total number of personnel working in the organization of respondents.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$
H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *quality risk factor* scores for each range for total number of personnel working in the organization of respondents.

DESCRIPTIVES

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0-5	40	6,831760	1,8680695	,2953677	6,234323	7,429198	3,5038	11,1122
6-10	26	7,452463	1,9390834	,3802855	6,669250	8,235675	3,6735	12,4694
11-20	17	6,181723	2,2879735	,5549151	5,005355	7,358090	3,1569	11,0115
21-30	8	7,397481	1,8133084	,6411013	5,881517	8,913445	5,5357	10,7946
30+	59	7,083297	2,1997021	,2863768	6,510052	7,656543	2,5370	12,7500
Total	150	6,994787	2,0676861	,1688259	6,661185	7,328390	2,5370	12,7500

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19,507	4	4,877	1,145	**,338**
Within Groups	617,517	145	4,259		
Total	637,024	149			

ANOVA test result gives a p-value of 0,338. Since this p-value is greater than α=0,05 significance level, the null hypothesis, H_0, was accepted. And it was concluded that there is "no difference between the population means of the *quality risk factor* scores according to total number of personnel working in the organization of respondents".

APPENDIX D

ONE WAY WITHIN ANOVA RESULTS

D.1 Seek for statistically significant difference of the average frequency of occurrence values of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2,517	,064	2,389	2,644
2	2,699	,042	2,617	2,782
3	2,639	,032	2,575	2,703
4	2,402	,041	2,322	2,483
5	2,268	,042	2,184	2,352
6	2,694	,040	2,615	2,772
7	2,709	,063	2,583	2,834
8	2,377	,068	2,244	2,511

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,132	299,009	27	,000	,674	,698	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]

Category	Pillai's Trace	,471	18,346[b]	7,000	144,000	,000	,471	128,423	1,000
	Wilks' Lambda	,529	18,346[b]	7,000	144,000	,000	,471	128,423	1,000
	Hotelling's Trace	,892	18,346[b]	7,000	144,000	,000	,471	128,423	1,000
	Roy's Largest Root	,892	18,346[b]	7,000	144,000	,000	,471	128,423	1,000

a. Design: Intercept

Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-,183	,064	,136	-,386	,021
	3	-,123	,062	1,000	-,319	,074
	4	,114	,063	1,000	-,086	,314
	5	,248*	,076	,037	,007	,490
	6	-,177	,065	,192	-,383	,028
	7	-,192	,082	,564	-,452	,068
	8	,139	,079	1,000	-,113	,391
2	1	,183	,064	,136	-,021	,386
	3	,060	,038	1,000	-,061	,181
	4	,297*	,040	,000	,169	,426
	5	,431*	,054	,000	,261	,601
	6	,006	,032	1,000	-,096	,107
	7	-,009	,062	1,000	-,208	,189
	8	,322*	,063	,000	,120	,524
3	1	,123	,062	1,000	-,074	,319
	2	-,060	,038	1,000	-,181	,061
	4	,237*	,038	,000	,115	,359
	5	,371*	,046	,000	,224	,518
	6	-,055	,033	1,000	-,160	,051
	7	-,070	,065	1,000	-,275	,136
	8	,262*	,063	,002	,060	,463

4	1	-,114	,063	1,000	-,314	,086
	2	-,297*	,040	,000	-,426	-,169
	3	-,237*	,038	,000	-,359	-,115
	5	,134	,044	,085	-,007	,276
	6	-,291*	,038	,000	-,413	-,170
	7	-,306*	,059	,000	-,494	-,118
	8	,025	,058	1,000	-,160	,210
5	1	-,248*	,076	,037	-,490	-,007
	2	-,431*	,054	,000	-,601	-,261
	3	-,371*	,046	,000	-,518	-,224
	4	-,134	,044	,085	-,276	,007
	6	-,425*	,045	,000	-,570	-,281
	7	-,440*	,064	,000	-,643	-,238
	8	-,109	,070	1,000	-,332	,113
6	1	,177	,065	,192	-,028	,383
	2	-,006	,032	1,000	-,107	,096
	3	,055	,033	1,000	-,051	,160
	4	,291*	,038	,000	,170	,413
	5	,425*	,045	,000	,281	,570
	7	-,015	,055	1,000	-,190	,160
	8	,316*	,064	,000	,112	,520
7	1	,192	,082	,564	-,068	,452
	2	,009	,062	1,000	-,189	,208
	3	,070	,065	1,000	-,136	,275
	4	,306*	,059	,000	,118	,494
	5	,440*	,064	,000	,238	,643
	6	,015	,055	1,000	-,160	,190
	8	,331*	,083	,003	,068	,595
8	1	-,139	,079	1,000	-,391	,113
	2	-,322*	,063	,000	-,524	-,120
	3	-,262*	,063	,002	-,463	-,060
	4	-,025	,058	1,000	-,210	,160
	5	,109	,070	1,000	-,113	,332
	6	-,316*	,064	,000	-,520	-,112
	7	-,331*	,083	,003	-,595	-,068

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

D.2 Seek for statistically significant difference of the average impact over cost values of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2,656	,069	2,519	2,792
2	2,721	,045	2,632	2,809
3	2,540	,041	2,458	2,622
4	2,275	,046	2,184	2,366
5	2,338	,050	2,238	2,437
6	2,701	,044	2,614	2,788
7	2,530	,068	2,395	2,665
8	2,238	,068	2,104	2,373

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,162	268,450	27	,000	,688	,713	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Category	Pillai's Trace	,545	24,599[b]	7,000	144,000	,000	,545	172,190	1,000
	Wilks' Lambda	,455	24,599[b]	7,000	144,000	,000	,545	172,190	1,000
	Hotelling's Trace	1,196	24,599[b]	7,000	144,000	,000	,545	172,190	1,000

	Roy's Largest Root	1,196	24,599[b]	7,000	144,000	,000	,545	172,190	1,000

a. Design: Intercept
 Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-,065	,062	1,000	-,262	,132
	3	,116	,070	1,000	-,106	,338
	4	,381*	,069	,000	,161	,601
	5	,318*	,072	,001	,089	,547
	6	-,046	,065	1,000	-,252	,161
	7	,126	,087	1,000	-,152	,403
	8	,417*	,080	,000	,163	,671
2	1	,065	,062	1,000	-,132	,262
	3	,181*	,041	,001	,051	,311
	4	,446*	,041	,000	,314	,577
	5	,383*	,048	,000	,231	,535
	6	,019	,034	1,000	-,087	,126
	7	,191	,068	,162	-,026	,407
	8	,482*	,065	,000	,276	,688
3	1	-,116	,070	1,000	-,338	,106
	2	-,181*	,041	,001	-,311	-,051
	4	,265*	,044	,000	,126	,404
	5	,202*	,047	,001	,053	,351
	6	-,161*	,035	,000	-,272	-,050
	7	,010	,068	1,000	-,208	,228
	8	,301*	,067	,000	,088	,514

4	1	-,381*	,069	,000	-,601	-,161
	2	-,446*	,041	,000	-,577	-,314
	3	-,265*	,044	,000	-,404	-,126
	5	-,063	,049	1,000	-,217	,092
	6	-,426*	,042	,000	-,559	-,293
	7	-,255*	,061	,002	-,450	-,060
	8	,036	,061	1,000	-,157	,230
5	1	-,318*	,072	,001	-,547	-,089
	2	-,383*	,048	,000	-,535	-,231
	3	-,202*	,047	,001	-,351	-,053
	4	,063	,049	1,000	-,092	,217
	6	-,363*	,043	,000	-,499	-,228
	7	-,192	,069	,171	-,412	,028
	8	,099	,064	1,000	-,104	,303
6	1	,046	,065	1,000	-,161	,252
	2	-,019	,034	1,000	-,126	,087
	3	,161*	,035	,000	,050	,272
	4	,426*	,042	,000	,293	,559
	5	,363*	,043	,000	,228	,499
	7	,171	,061	,166	-,024	,367
	8	,463*	,063	,000	,262	,663
7	1	-,126	,087	1,000	-,403	,152
	2	-,191	,068	,162	-,407	,026
	3	-,010	,068	1,000	-,228	,208
	4	,255*	,061	,002	,060	,450
	5	,192	,069	,171	-,028	,412
	6	-,171	,061	,166	-,367	,024
	8	,291*	,084	,019	,025	,558
8	1	-,417*	,080	,000	-,671	-,163
	2	-,482*	,065	,000	-,688	-,276
	3	-,301*	,067	,000	-,514	-,088
	4	-,036	,061	1,000	-,230	,157
	5	-,099	,064	1,000	-,303	,104
	6	-,463*	,063	,000	-,663	-,262
	7	-,291*	,084	,019	-,558	-,025

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

D.3 Seek for statistically significant difference of the average impact over duration values of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2,874	,071	2,735	3,013
2	2,938	,044	2,850	3,025
3	2,969	,038	2,895	3,044
4	2,523	,045	2,434	2,613
5	2,553	,049	2,456	2,650
6	2,940	,044	2,852	3,027
7	2,768	,071	2,629	2,908
8	2,358	,070	2,219	2,496

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,148	281,549	27	,000	,670	,694	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Category	Pillai's Trace	,601	31,009[b]	7,000	144,000	,000	,601	217,064	1,000
	Wilks' Lambda	,399	31,009[b]	7,000	144,000	,000	,601	217,064	1,000
	Hotelling's Trace	1,507	31,009[b]	7,000	144,000	,000	,601	217,064	1,000

	Roy's Largest Root	1,507	31,009[b]	7,000	144,000	,000	,601	217,064	1,000

a. Design: Intercept
 Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-,064	,066	1,000	-,273	,146
	3	-,095	,062	1,000	-,294	,104
	4	,351*	,069	,000	,133	,569
	5	,321*	,074	,001	,085	,557
	6	-,065	,065	1,000	-,271	,141
	7	,106	,090	1,000	-,179	,391
	8	,517*	,079	,000	,265	,768
2	1	,064	,066	1,000	-,146	,273
	3	-,031	,041	1,000	-,162	,099
	4	,415*	,041	,000	,283	,546
	5	,385*	,045	,000	,241	,529
	6	-,002	,036	1,000	-,115	,112
	7	,170	,067	,347	-,043	,383
	8	,580*	,070	,000	,358	,802
3	1	,095	,062	1,000	-,104	,294
	2	,031	,041	1,000	-,099	,162
	4	,446*	,045	,000	,304	,588
	5	,416*	,048	,000	,265	,567
	6	,030	,035	1,000	-,081	,140
	7	,201	,070	,133	-,022	,424
	8	,611*	,065	,000	,404	,819

	1	-,351*	,069	,000	-,569	-,133
	2	-,415*	,041	,000	-,546	-,283
	3	-,446*	,045	,000	-,588	-,304
4	5	-,030	,045	1,000	-,172	,112
	6	-,416*	,041	,000	-,547	-,286
	7	-,245*	,067	,010	-,458	-,032
	8	,166	,066	,380	-,045	,376
	1	-,321*	,074	,001	-,557	-,085
	2	-,385*	,045	,000	-,529	-,241
	3	-,416*	,048	,000	-,567	-,265
5	4	,030	,045	1,000	-,112	,172
	6	-,387*	,038	,000	-,508	-,265
	7	-,215	,069	,059	-,434	,004
	8	,195	,065	,086	-,011	,402
	1	,065	,065	1,000	-,141	,271
	2	,002	,036	1,000	-,112	,115
	3	-,030	,035	1,000	-,140	,081
6	4	,416*	,041	,000	,286	,547
	5	,387*	,038	,000	,265	,508
	7	,171	,064	,232	-,032	,375
	8	,582*	,064	,000	,377	,787
	1	-,106	,090	1,000	-,391	,179
	2	-,170	,067	,347	-,383	,043
	3	-,201	,070	,133	-,424	,022
7	4	,245*	,067	,010	,032	,458
	5	,215	,069	,059	-,004	,434
	6	-,171	,064	,232	-,375	,032
	8	,411*	,086	,000	,136	,685
	1	-,517*	,079	,000	-,768	-,265
	2	-,580*	,070	,000	-,802	-,358
	3	-,611*	,065	,000	-,819	-,404
8	4	-,166	,066	,380	-,376	,045
	5	-,195	,065	,086	-,402	,011
	6	-,582*	,064	,000	-,787	-,377
	7	-,411*	,086	,000	-,685	-,136

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

D.4 Seek for statistically significant difference of the average impact over quality of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2,596	,072	2,453	2,739
2	2,874	,050	2,776	2,972
3	2,543	,041	2,463	2,624
4	2,387	,047	2,294	2,481
5	2,434	,055	2,324	2,543
6	2,820	,046	2,729	2,910
7	2,947	,065	2,819	3,075
8	1,960	,066	1,829	2,091

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,150	279,629	27	,000	,682	,708	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Category	Pillai's Trace	,631	35,217[b]	7,000	144,000	,000	,631	246,518	1,000
	Wilks' Lambda	,369	35,217[b]	7,000	144,000	,000	,631	246,518	1,000
	Hotelling's Trace	1,712	35,217[b]	7,000	144,000	,000	,631	246,518	1,000

	Roy's Largest Root	1,712	35,217[b]	7,000	144,000	,000	,631	246,518	1,000

a. Design: Intercept

Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-,278*	,066	,001	-,490	-,067
	3	,053	,067	1,000	-,159	,265
	4	,209	,069	,084	-,011	,428
	5	,162	,079	1,000	-,089	,413
	6	-,224*	,067	,029	-,436	-,011
	7	-,351*	,087	,002	-,627	-,075
	8	,636*	,083	,000	,373	,899
2	1	,278*	,066	,001	,067	,490
	3	,331*	,043	,000	,194	,468
	4	,487*	,045	,000	,344	,629
	5	,440*	,057	,000	,259	,621
	6	,055	,035	1,000	-,058	,168
	7	-,073	,061	1,000	-,268	,122
	8	,914*	,073	,000	,683	1,145
3	1	-,053	,067	1,000	-,265	,159
	2	-,331*	,043	,000	-,468	-,194
	4	,156*	,043	,012	,018	,293
	5	,109	,046	,497	-,036	,254
	6	-,276*	,033	,000	-,382	-,171
	7	-,404*	,063	,000	-,606	-,202
	8	,583*	,064	,000	,378	,787

4	1	-,209	,069	,084	-,428	,011
	2	-,487*	,045	,000	-,629	-,344
	3	-,156*	,043	,012	-,293	-,018
	5	-,046	,046	1,000	-,194	,101
	6	-,432*	,042	,000	-,565	-,299
	7	-,560*	,064	,000	-,762	-,357
	8	,427*	,062	,000	,230	,625
5	1	-,162	,079	1,000	-,413	,089
	2	-,440*	,057	,000	-,621	-,259
	3	-,109	,046	,497	-,254	,036
	4	,046	,046	1,000	-,101	,194
	6	-,386*	,047	,000	-,534	-,238
	7	-,513*	,064	,000	-,718	-,308
	8	,474*	,072	,000	,246	,701
6	1	,224*	,067	,029	,011	,436
	2	-,055	,035	1,000	-,168	,058
	3	,276*	,033	,000	,171	,382
	4	,432*	,042	,000	,299	,565
	5	,386*	,047	,000	,238	,534
	7	-,127	,057	,771	-,310	,055
	8	,859*	,067	,000	,648	1,071
7	1	,351*	,087	,002	,075	,627
	2	,073	,061	1,000	-,122	,268
	3	,404*	,063	,000	,202	,606
	4	,560*	,064	,000	,357	,762
	5	,513*	,064	,000	,308	,718
	6	,127	,057	,771	-,055	,310
	8	,987*	,084	,000	,721	1,252
8	1	-,636*	,083	,000	-,899	-,373
	2	-,914*	,073	,000	-1,145	-,683
	3	-,583*	,064	,000	-,787	-,378
	4	-,427*	,062	,000	-,625	-,230
	5	-,474*	,072	,000	-,701	-,246
	6	-,859*	,067	,000	-1,071	-,648
	7	-,987*	,084	,000	-1,252	-,721

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

D.5 Seek for statistically significant difference of the average cost risk value of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	7,026	,309	6,417	7,636
2	7,523	,217	7,095	7,952
3	6,815	,171	6,478	7,153
4	5,668	,192	5,288	6,048
5	5,467	,189	5,093	5,841
6	7,432	,204	7,028	7,835
7	7,159	,315	6,536	7,782
8	5,755	,297	5,168	6,342

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,124	308,037	27	,000	,640	,662	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Category	Pillai's Trace	,516	21,929[b]	7,000	144,000	,000	,516	153,502	1,000
	Wilks' Lambda	,484	21,929[b]	7,000	144,000	,000	,516	153,502	1,000
	Hotelling's Trace	1,066	21,929[b]	7,000	144,000	,000	,516	153,502	1,000

Roy's Largest Root	1,066	21,929[b]	7,000	144,000	,000	,516	153,502	1,000

a. Design: Intercept
Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-,497	,287	1,000	-1,409	,415
	3	,211	,300	1,000	-,742	1,164
	4	1,358*	,310	,001	,372	2,345
	5	1,560*	,338	,000	,486	2,634
	6	-,405	,299	1,000	-1,356	,546
	7	-,132	,418	1,000	-1,463	1,198
	8	1,272*	,376	,026	,076	2,467
2	1	,497	,287	1,000	-,415	1,409
	3	,708*	,183	,005	,125	1,291
	4	1,855*	,195	,000	1,235	2,475
	5	2,057*	,229	,000	1,328	2,785
	6	,092	,156	1,000	-,405	,589
	7	,365	,320	1,000	-,654	1,383
	8	1,768*	,291	,000	,844	2,693
3	1	-,211	,300	1,000	-1,164	,742
	2	-,708*	,183	,005	-1,291	-,125
	4	1,147*	,180	,000	,576	1,719
	5	1,348*	,200	,000	,712	1,985
	6	-,616*	,152	,002	-1,101	-,131
	7	-,344	,316	1,000	-1,350	,663
	8	1,060*	,284	,008	,156	1,965

	1	-1,358*	,310	,001	-2,345	-,372
	2	-1,855*	,195	,000	-2,475	-1,235
	3	-1,147*	,180	,000	-1,719	-,576
4	5	,201	,185	1,000	-,387	,789
	6	-1,764*	,185	,000	-2,351	-1,176
	7	-1,491*	,289	,000	-2,409	-,572
	8	-,087	,266	1,000	-,934	,760
	1	-1,560*	,338	,000	-2,634	-,486
	2	-2,057*	,229	,000	-2,785	-1,328
	3	-1,348*	,200	,000	-1,985	-,712
5	4	-,201	,185	1,000	-,789	,387
	6	-1,965*	,190	,000	-2,569	-1,361
	7	-1,692*	,297	,000	-2,637	-,747
	8	-,288	,275	1,000	-1,162	,586
	1	,405	,299	1,000	-,546	1,356
	2	-,092	,156	1,000	-,589	,405
	3	,616*	,152	,002	,131	1,101
6	4	1,764*	,185	,000	1,176	2,351
	5	1,965*	,190	,000	1,361	2,569
	7	,273	,288	1,000	-,645	1,190
	8	1,677*	,280	,000	,786	2,568
	1	,132	,418	1,000	-1,198	1,463
	2	-,365	,320	1,000	-1,383	,654
	3	,344	,316	1,000	-,663	1,350
7	4	1,491*	,289	,000	,572	2,409
	5	1,692*	,297	,000	,747	2,637
	6	-,273	,288	1,000	-1,190	,645
	8	1,404*	,387	,011	,172	2,636
	1	-1,272*	,376	,026	-2,467	-,076
	2	-1,768*	,291	,000	-2,693	-,844
	3	-1,060*	,284	,008	-1,965	-,156
8	4	,087	,266	1,000	-,760	,934
	5	,288	,275	1,000	-,586	1,162
	6	-1,677*	,280	,000	-2,568	-,786
	7	-1,404*	,387	,011	-2,636	-,172

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

D.6 Seek for statistically significant difference of the average duration risk value of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	7,656	,322	7,019	8,292
2	8,121	,224	7,678	8,563
3	7,959	,177	7,609	8,308
4	6,273	,201	5,876	6,670
5	5,980	,198	5,588	6,372
6	8,078	,212	7,659	8,496
7	7,781	,324	7,140	8,422
8	6,046	,301	5,452	6,641

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,162	268,153	27	,000	,668	,692	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Category	Pillai's Trace	,550	25,131[b]	7,000	144,000	,000	,550	175,920	1,000
	Wilks' Lambda	,450	25,131[b]	7,000	144,000	,000	,550	175,920	1,000
	Hotelling's Trace	1,222	25,131[b]	7,000	144,000	,000	,550	175,920	1,000

	Roy's Largest Root	1,222	25,131[b]	7,000	144,000	,000	,550	175,920	1,000

a. Design: Intercept

Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-,465	,318	1,000	-1,475	,546
	3	-,303	,296	1,000	-1,246	,640
	4	1,382*	,318	,001	,372	2,393
	5	1,675*	,355	,000	,546	2,805
	6	-,422	,314	1,000	-1,422	,578
	7	-,126	,426	1,000	-1,480	1,228
	8	1,609*	,366	,001	,445	2,774
2	1	,465	,318	1,000	-,546	1,475
	3	,162	,202	1,000	-,480	,803
	4	1,847*	,208	,000	1,185	2,510
	5	2,140*	,239	,000	1,380	2,901
	6	,043	,167	1,000	-,488	,574
	7	,339	,321	1,000	-,684	1,362
	8	2,074*	,301	,000	1,116	3,032
3	1	,303	,296	1,000	-,640	1,246
	2	-,162	,202	1,000	-,803	,480
	4	1,685*	,198	,000	1,057	2,314
	5	1,978*	,216	,000	1,291	2,666
	6	-,119	,167	1,000	-,650	,412
	7	,177	,326	1,000	-,860	1,214
	8	1,912*	,281	,000	1,018	2,806

	1	-1,382*	,318	,001	-2,393	-,372
	2	-1,847*	,208	,000	-2,510	-1,185
	3	-1,685*	,198	,000	-2,314	-1,057
4	5	,293	,195	1,000	-,326	,912
	6	-1,804*	,190	,000	-2,410	-1,199
	7	-1,508*	,309	,000	-2,491	-,526
	8	,227	,277	1,000	-,654	1,108
	1	-1,675*	,355	,000	-2,805	-,546
	2	-2,140*	,239	,000	-2,901	-1,380
	3	-1,978*	,216	,000	-2,666	-1,291
5	4	-,293	,195	1,000	-,912	,326
	6	-2,097*	,194	,000	-2,714	-1,481
	7	-1,801*	,311	,000	-2,791	-,812
	8	-,066	,284	1,000	-,969	,836
	1	,422	,314	1,000	-,578	1,422
	2	-,043	,167	1,000	-,574	,488
	3	,119	,167	1,000	-,412	,650
6	4	1,804*	,190	,000	1,199	2,410
	5	2,097*	,194	,000	1,481	2,714
	7	,296	,292	1,000	-,632	1,224
	8	2,031*	,279	,000	1,145	2,917
	1	,126	,426	1,000	-1,228	1,480
	2	-,339	,321	1,000	-1,362	,684
	3	-,177	,326	1,000	-1,214	,860
7	4	1,508*	,309	,000	,526	2,491
	5	1,801*	,311	,000	,812	2,791
	6	-,296	,292	1,000	-1,224	,632
	8	1,735*	,392	,001	,489	2,981
	1	-1,609*	,366	,001	-2,774	-,445
	2	-2,074*	,301	,000	-3,032	-1,116
	3	-1,912*	,281	,000	-2,806	-1,018
8	4	-,227	,277	1,000	-1,108	,654
	5	,066	,284	1,000	-,836	,969
	6	-2,031*	,279	,000	-2,917	-1,145
	7	-1,735*	,392	,001	-2,981	-,489

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

D.7 Seek for statistically significant difference of the average quality risk value of waste items in 8 waste categories

Estimates

Measure: MEASURE_1

Category	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	6,894	,312	6,278	7,510
2	7,970	,235	7,506	8,435
3	6,823	,169	6,489	7,157
4	5,950	,198	5,558	6,342
5	5,695	,199	5,302	6,089
6	7,769	,214	7,346	8,193
7	8,377	,335	7,715	9,040
8	4,980	,275	4,436	5,524

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Category	,119	314,172	27	,000	,644	,666	,143

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: Category

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Category	Pillai's Trace	,575	27,791[b]	7,000	144,000	,000	,575	194,540	1,000
	Wilks' Lambda	,425	27,791[b]	7,000	144,000	,000	,575	194,540	1,000
	Hotelling's Trace	1,351	27,791[b]	7,000	144,000	,000	,575	194,540	1,000

	Roy's Largest Root	1,351	27,791[b]	7,000	144,000	,000	,575	194,540	1,000

a. Design: Intercept

Within Subjects Design: Category

b. Exact statistic

c. Computed using alpha = ,05

Pairwise Comparisons

Measure: MEASURE_1

(I) Category	(J) Category	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-1,076*	,305	,015	-2,045	-,107
	3	,071	,293	1,000	-,859	1,002
	4	,944	,307	,070	-,033	1,920
	5	1,199*	,348	,021	,092	2,305
	6	-,875	,310	,153	-1,863	,112
	7	-1,483*	,427	,019	-2,842	-,125
	8	1,914*	,355	,000	,784	3,044
2	1	1,076*	,305	,015	,107	2,045
	3	1,147*	,194	,000	,530	1,765
	4	2,020*	,202	,000	1,378	2,662
	5	2,275*	,252	,000	1,473	3,076
	6	,201	,166	1,000	-,327	,729
	7	-,407	,325	1,000	-1,441	,627
	8	2,990*	,294	,000	2,056	3,924
3	1	-,071	,293	1,000	-1,002	,859
	2	-1,147*	,194	,000	-1,765	-,530
	4	,873*	,182	,000	,295	1,451
	5	1,128*	,188	,000	,530	1,726
	6	-,946*	,153	,000	-1,434	-,458
	7	-1,554*	,324	,000	-2,584	-,525
	8	1,843*	,271	,000	,982	2,703

4	1	-,944	,307	,070	-1,920	,033
	2	-2,020*	,202	,000	-2,662	-1,378
	3	-,873*	,182	,000	-1,451	-,295
	5	,255	,180	1,000	-,318	,828
	6	-1,819*	,185	,000	-2,409	-1,229
	7	-2,427*	,309	,000	-3,410	-1,444
	8	,970*	,254	,006	,161	1,779
5	1	-1,199*	,348	,021	-2,305	-,092
	2	-2,275*	,252	,000	-3,076	-1,473
	3	-1,128*	,188	,000	-1,726	-,530
	4	-,255	,180	1,000	-,828	,318
	6	-2,074*	,204	,000	-2,722	-1,426
	7	-2,682*	,312	,000	-3,674	-1,691
	8	,715	,270	,249	-,143	1,574
6	1	,875	,310	,153	-,112	1,863
	2	-,201	,166	1,000	-,729	,327
	3	,946*	,153	,000	,458	1,434
	4	1,819*	,185	,000	1,229	2,409
	5	2,074*	,204	,000	1,426	2,722
	7	-,608	,286	,981	-1,517	,301
	8	2,789*	,272	,000	1,924	3,654
7	1	1,483*	,427	,019	,125	2,842
	2	,407	,325	1,000	-,627	1,441
	3	1,554*	,324	,000	,525	2,584
	4	2,427*	,309	,000	1,444	3,410
	5	2,682*	,312	,000	1,691	3,674
	6	,608	,286	,981	-,301	1,517
	8	3,397*	,378	,000	2,194	4,601
8	1	-1,914*	,355	,000	-3,044	-,784
	2	-2,990*	,294	,000	-3,924	-2,056
	3	-1,843*	,271	,000	-2,703	-,982
	4	-,970*	,254	,006	-1,779	-,161
	5	-,715	,270	,249	-1,574	,143
	6	-2,789*	,272	,000	-3,654	-1,924
	7	-3,397*	,378	,000	-4,601	-2,194

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.