Examining The Utilization of Scrum by Engineering Consultants to Manage Construction Projects from Initiation until Closing

دراسة لإستخدام الإستشاريين الهندسيين لمنهجية سكروم لإدارة المشاريع الإنشائية من مرحلة البدء ما قبل التصميم لحين إكتمال المشاريع و تسليمها

By

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Abstract

The construction industry is considered a key contributing factor to almost every countries' economy. Taking that into account, having strong, stable and successfully completed projects from A to Z is a vital component in determining the further development of a countries infrastructure and its position within the market and overall GDP. As of decades past, construction projects have been managed by applying the traditional project management methodologies or what is known as waterfall methodology, which is sequential in nature where construction activities flow in a sequence (a finish to start relationship). This sequential pattern also applies to other project phases, such as pre and post construction phase (execution phase). Many projects around the world have been successfully completed, in terms of time and cost, when managed by the traditional methodology, but at the same time there have been many that have not reached completion in particular complex projects or mega projects where multiple parties are involved. Construction projects go through many phases before it remotely reaches the construction phase (Execution phase), which is usually executed and completed by a contractor after the project has been designed and specified by a consultant. The role and involvement of a Client in construction projects is usually shallow and their main communication is with the project consultant as it is the responsibility of the project consultant to manage proper execution and timeline. The consultant's role exceeds beyond the design phase into supervision as the project commences and begins to be erected from the ground up as well as work as the client's representative in monitoring the project's duration, cost and even selecting materials on behalf of the client. Clients usually do not get deeply involved in their projects due to their limited experience and knowledge in this type of works and so they go on to

hire consultants on their behalf, which in many cases creates conflict and may cause delays and cost overrun due to rework and losses of materials.

Throughout decades, many professionals in construction and managing construction projects tried to apply different methodologies and solutions striving for the completion of successful projects that were on time and within budget and most importantly matched the client's desires and expectations.

One of the latest project management methodologies is Scrum, which is considered an agile methodology. This methodology has many features that can be utilized to enhance managing construction projects by the traditional methodology. This research will discuss the utilization of Scrum in managing construction projects from a consultant's point of view, since it can be applied in many phases apart from the construction phase, which is usually handled by contractors and in general wider than client's scope in managing construction projects.

Scrum may not be a comprehensive methodology to manage construction projects, but it has proved to be sufficient and effective when applied in certain phases, or in managing certain activities within certain phases.

This research will describe Scrum in depth, show results from applying Scrum as the only methodology to manage certain phases, how it can be combined with the traditional methodology to accomplish the desired results, and how Scrum can positively affect time, cost, and overall client satisfaction.

ملخص

تعتبر صناعة البناء و التشييد عامل مساهم مهم في اقتصاد كل دولة. عند أخذ هذا في الحسبان فإن تشييد أبنية ومشاريع ناجحة من البداية للنهاية يعتبر عنصر أساسي لتحديد مدى تطور بلد معين و مدى تطور البنية التحتية لهذا البلد و كيف يساهم هذا البنيان والمشاريع من الناتج القومي المحلي. خلال العقود الماضية كان يتم إدارة المشاريع الإنشائية من خلال استعمال المنهجية التقليدية لإداة المشاريع أو ما يسمى بالمنهجية الشلالية و ذلك لأنها منهجية تتابعية في طبيعتها تعتمد على تتابع النشاطات واحد تلو الآخر. الكثير من المشاريع الإنشائية تم إتمامها بنجاح من خلال استخدام المنهجية التقليدية لإدارة المشاريع، لكن من جانب آخر الكثير من المشاريع لم يتم إتمامها أو تمت لكن مع وجود الكثير من التأخير في مدة المشاريع و وجود كلفة إضافية، خاصة المشاريع الكبيرة المعقدة. المشاريع الإنشائية عادة تمر بمراحل عديدة مثل التصميم و الإنشاء الذي عادة يتم من خلال مقاول و مرحلة إنهاء المشروع، لكن خلال المراحل كلها و عند استخدام المنهدية التقليدية لإدارة المشاريع فإن تفاعل العميل ضعيف جدا حيث عادة ما يكون الإستشاري هو المهندس الذي يتابع أعمال الإنشاء و جدول المشروع واختيار المواد و الكلفة و غيرها من الأعمال التي في كثير من الأحيان العميل لا يتدخل بها لقلة خبرته بها أو لمجرد تسليمها للإستشاري مما يؤدي في العديد من المشاريع إلى حدوث خلافات و تأخير و زيادة كلفة المشاريع.

خلال العقود الماضية حاول العديد من أصحاب الخبرة في مجال إدارة المشاريع الإنشائية إيجاد حلول و منهجيات ليتم تطبيقها لإدارة المشاريع الإنشائية لتساهم في إنشاء و استكمال المشاريع بنجاح. واحدة من هذه النظريات هي سكروم والتي تعد واحدة من منهجيات إدارة المشاريع الحديثة الرشيقة التي يتم استخدامها بشكل واسع في مجال إدارة المعلومات و البرمجيات. في هذا البحث سيتم شرح سكروم بالتفصيل بكل مميزاته و كيف يمكن إستخدام هذه المنهجية والتي يمكن أن يعدّها الكثير منهجية غير مكتملة لإدارة عمليات و مراحل مختلفة خلال حياة المشاريع الإنشائية.

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Chapter 1: Introduction

This section presents a background of the research problem, which are downfalls that come up with practicing the traditional project management methodology in managing construction projects from initiation until closing. The background demonstrates certain issues that affect construction projects' time, cost and overall performance. This section demonstrates the research aim, research questions, and research objectives. Clear scope of work is highlighted within this section along with the dissertation structure.

1.1Background

The topic of project management has taken a big chunk of studies and development during the past decades around all the world in order to deliver successful projects with clear acceptable deliverables. Professionals around the world have become and still becoming more familiar and interested in applying not only the trendiest, but the most effective methodologies and techniques in order to accomplish the required and desired results. Example of the main certifications that attract most of professionals in the project management world is the PMP (Project Management Professional) which is a certification by the (PMI) Project management Institution. Webster (1994) claims that the Project Management Institute (PMI) is one of the most popular and leading project management entities in the world that was founded in 1969. Webster (1994) adds that the PMP certification first came in 1984 and is considered the most important certification in the project management domain.

According to the Project Management Institute (PMI), the Project Management Body of Knowledge (PMBOK) is the guide book to prepare for the PMP certification and gain proper knowledge that assist and steer professionals in managing projects by providing the necessary tools, techniques and practice guides.

Before going deeper, it is necessary to understand the meaning of project management and the importance of it for organizations and projects.

According to the Project Management Institute (PMI 2013) project management is "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements". According to the APM (Association for The Project Management), "Project management is the application of processes, methods, skills, knowledge and experience to

achieve specific project objectives according to the project acceptance criteria within agreed parameters. Project management has final deliverables that are constrained to a finite timescale and budget." These definitions apply to any project in any industry and not only construction or engineering projects and both definitions from these two different organizations show that project management basically is applying certain techniques, tools and knowledge to achieve desired requirements and final product. But to manage projects in general, certain type of knowledge and certain methodologies need to be placed and practiced to achieve the final required results and product, especially in projects that have enormous amount of activities and requirements such as construction projects. According to Ozmen (2013), adopting suitable project management methodology by organizations is crucial and can determine what an organization's efforts will lead to and if it will be effective enough or not. Also Ozmen (2013), stresses that managing successful projects means having successful organizations and from there comes the importance of project management. Through the past years, managing projects by professionals and Project Managers was by applying the traditional project management methodology or the waterfall methodology. Fitsilis (2008) Claims that the Project Management Body of Knowledge (PMBOK) by the (PMI) is the best example of the traditional project management methodology where on the other hand, Silger (2008) highlights that the PMBOK does not adopt or advocate any specific project management methodology and keep it open to practitioners to select the best methodology that suits each project.

Even though the PMBOK does not clearly dictate a methodology to be followed, the application of the traditional methodology can be recognized by tracking the main process groups that are organized in a sequential manner in the PMBOK. The process groups are Initiation, Planning,

Execution, Monitoring and Controlling, and Closing. Figure (11) illustrates the relation and the sequence of all five process groups.

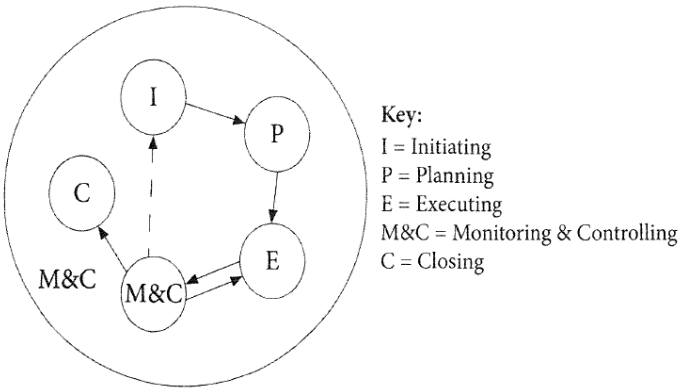

Figure (1). Project Management Processes- Mulcahy 2013, P. 37

From figure (1) it can be observed that the five process groups go into a sequence starting with the initiation process group and ends with the closing process group, in an environment of monitoring and controlling

But what is the most commonly used project management methodology in the construction world?

When it comes to managing engineering projects through different phases from design, execution, to closing, the traditional methodology is the primary methodology to do the same. According to (Alzwainy, Mohammed, & Raheem 2016), the traditional methodology is the most common used methodology in construction, where it's based on sequential phases. According to

Fair (2012), when applying the waterfall methodology, activities within projects are linear (sequential). According to Straçusser (2015), the common aspect between all construction projects is the sequential factor. As mentioned by Straçusser (2015), "Typical construction projects have an initiation/planning phase, a design phase, a construction phase, a testing phase, and a turnover to the user phase, followed by project closeout". Also, during the construction phase itself, another sequence of activities happens and planned out in a schedule.

On the other hand, in a research by Jin (2017) states that according to (Turner 2014), even though Project Managers have been using traditional methodologies for years to manage different construction projects, using agile project management methodologies in the construction industry came as an alternative instead of the traditional methodology which has weaknesses associated with it.

Figure (1) shows that all process groups are performing under one process group that must exist in all other process groups with is Monitoring and Controlling. According to the PMI (2013), the monitoring and controlling process group act as a background for all other process groups and interact with all of them. From another stand point, according to (Tengan & Aigbavboa 2018), applying proper monitoring and controlling is not consistent throughout projects' life cycles and it's poorly misunderstood by teams and Project Managers, which affect projects' performance in general. According to a research by Puspasari (2005), even though many monitoring and controlling guidelines do exist, still many construction projects are facing difficulties to meet their objectives.

Despite the fact of having clear guidelines from the PMBOK regarding monitoring and controlling and the importance of it, applying that in real life projects, and specifically

construction projects within the traditional methodology is somehow inefficient and insufficient due to the dynamic nature of the industry itself and the enormous amount of activities that occur in each process group.

One of the PMBOK knowledge areas is project stakeholder management, where it focuses on understanding stakeholders' expectations and aligning that with the project's final objectives, also, it aims to identify stakeholders' participation in their project and keeping constant communications with them to ensure their satisfaction, understanding their needs and expectations and to avoid conflicts. Another area where clients or key stakeholders in general are a point of interest is the initiation process group. According to the (PMI 2013), the purpose of this process is to highlight the project's scope to customers, clarify how their participation can assist in achieving the project's goals and objectives, and to match their requirements and expectations with the project's final objectives. On the other hand (Kerzner 2003) claims that the traditional methodology have many downfalls where Customers and their needs are not an essential factor, Coordinating between concerned parties usually complicated, decision making process is not facilitated as it should be, and taken decisions are based on the strength of certain functional departments. According to Bowie (2003), the 10 knowledge areas exist in the PMBOK are essential to deliver successful projects but are not sufficient, and a more customer driven approach needs to be applied to accomplish projects on time, within budget and to satisfy customer needs and expectations. Fair (2012) Have mentioned some characteristics of the waterfall methodology, which contains some downfalls when it comes to managing construction projects like low customer involvement in the project except the beginning and end of it.

The traditional project management methodology, represented by the PMBOK, may encourages and supports client involvement during projects, but in real life and during different process

groups in construction projects, it can be observed that there is a lack in proper clients' involvement and is not being customer driven which may affect time and cost by having many changes by clients due to nature of projects or not meeting clients expectations.

Recently, many organizations and professionals have already started involving their clients in their projects which make clients aware of the progress, see results and approve it one by one, and make changes in early stages like design stages and early stages of construction which leads to lower costs and higher clients' satisfaction. Changes are inevitable in construction projects, but the key point is to have better control over these changes and do the necessary of them with the lowest possible cost and time and that is always better when clients are intensively involved in their projects. According to Fair (2012), any changes after completion do cost a lot and not recommended in general.

Also, client's and stakeholders' frustration was notable when practicing the traditional project management methodology in projects which obviously is generated from not having the desired deliverables or having difficulties in delivering their requirements.

When it comes to late processes in a project's life cycle like the closing process group there is still a lot to be done and accomplished such as documenting lessons learned, archiving all necessary document, obtaining necessary approvals from the client to start with the closing processes..etc.

Another issue recognized in the traditional project management methodology that it is static in nature while the whole construction industry and construction projects known for being dynamic. According to Nassar (2009) the environment of construction project are competitive and therefore it is dynamic and complex. Ganis (n.d), claims many downfalls of the waterfall methodology such as focusing on having rigid and inflexible requirements and specifications in

early stages of projects like the design phase before even commencing in works in the execution phase. According to Shen (1996), continuous changes and actions keep occurring within construction projects due to the dynamic nature of these projects.

The following points are to sum up the major downfalls of the traditional (Waterfall) methodology in managing construction projects and other processes that precedes and succeeds the construction (execution) process:

1. Low customer/client involvement in most of the processes including the execution process
2. Monitoring and controlling overall in different processes is not sufficient due to the enormous amount of work, activities, and details involved
3. Inefficient identifying and documenting of lessons learned
4. The static nature of the traditional project management methodology does not coordinate with the dynamic nature of the construction industry and construction projects

From the above, it can be observed that the traditional project management methodology may not always be always the ideal methodology to manage construction projects or other processes that precedes or follow the construction (execution process), especially in mega complex projects where handing over on time and within budget are extremely important along with achieving customer satisfaction. Many professionals in the construction industry around the world started applying and testing the application of different methodologies and ideas to improve the traditional methodology in managing such projects or implementing new methodologies to manage certain phases or processes on its own. One of the latest trends in project management

nowadays is Agile Project Management, which expanded to have multiple methodologies like Scrum, Lean, Kanban, and other methodologies. Scrum will be the methodology in focus of this research.

1.2 Research Aim

This research aims to examine utilizing Scrum in managing multiple construction project's phases from initiation until closing, as well as the impact of Scrum on project timelines, cost and client involvement. The research will highlight the role of Project Managers while practicing Scrum framework and highlight effective recommendations and solutions that can be adopted to add value and facilitate processes with a structured purpose for defined outcomes and ultimately organized, on time project completions.

1.3 Research Questions

1. Where can Scrum be utilized in managing construction projects from a consultant's point of view?
2. How Project Managers (Consultants) can practice Scrum in managing projects through different phases
3. What is the impact of utilizing Scrum in different phases of construction projects regarding time, costs, risks, and client involvement in their projects?

1.4 Research Objectives

1. Examine the utilization of Scrum in managing different project processes to deliver the final desired outcome
2. Highlight Project Managers' role as a product owner when applying Scrum framework to manage different phases

3. Highlight the advantages of applying Scrum to manage multiple construction projects' processes (From initiation until closing) and the impact of that regarding time, costs, and client involvement

1.5 Scope of Work

This research intends to demonstrate how Scrum can be utilized by engineering consultants to manage the PMBOK five process groups in a project lifecycle. The research shows how can Scrum be an added value to the project overall, and how it is more beneficial to be used in certain phases than the others along with highlighting the Project Manager role while practicing this Scrum and how Project Managers' skills can fit within Scrum framework. The research will highlight main advantages of applying this methodology into different phases in a project lifecycle.

1.6 Dissertation Structure

The dissertation was structured in a way that enables the reader to understand the importance of why this research is needed and have a smooth flow of ideas and information in all sections. Chapter one aims to give an introduction and background of the traditional project management methodology and what are its weaknesses in managing construction projects. Also, in Chapter one the research aims questions and objectives which are presented along with the scope of work. Chapter two is the literature review where Scrum's history, framework, and roles are broken down and also in this chapter it presents how Scrum can be applied when managing construction projects through different processes. Chapter 3 sheds light on the conceptual framework along with the research hypothesis. Chapter 4 is concerned with the research

methodology where it highlights the philosophy, methodology, and approach of this research and why specifically they were selected. Chapter 4 also demonstrates the research questionnaire, how it was distributed, the sample that has taken the questionnaire and based on what it was selected, and finally it highlights the dependent and independent variables.

Chapter five presents the analysis of the collected data from the questionnaire. It shows supporting evidence as to if the data collected is reliable or not, correlation between dependent and independent variables, regression analysis, and finally testing the developed hypothesis.

Chapter six shows descriptive analysis of the collected data as it illustrates how Scrum can be applied and how effective it can be in managing construction projects through the five process groups and how that differs or approves the critically reviewed literature. Also in chapter six, the Project Manager and the effect of Scrum on projects' overall performance are discussed based on the descriptive analysis. Finally, Chapter seven has the conclusion of this research along with recommendations of future researches and the limitations of this research work.

Chapter2: The Literature Review

The researcher picked and critically reviewed the available literature to obtain reliable data that can be helpful to provide the basis for this research by developing an understanding of Scrum and examining its application to manage construction projects, while highlighting its strengths and test if it can overcome many downfalls in the traditional project management methodology. The literature review aims to establish a solid knowledge as secondary data in this research that can be compared and tested after collecting the principal data of this research by a survey questionnaire. The approach of this literature review will be a deductive approach since the Scrum framework is already established and the researcher will examine applying it in construction projects in the five PMBOK process groups and determine if Scrum's features and characteristics can be an added value to the process overall.

2.1 The Definition of Scrum

As defined by Schwaber &Sutherland (2017), "Scrum is a framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value".

What can be observed from Scrum's definition is that it's an adaptable framework to manage problems while in parallel delivering results in the desirable quality. The Scrum methodology depends on managing a project or certain phase/s of it while delivering other adaptable phases or parts of the same project.

2.1.1 History of Scrum

Referring to a recent paper Sliger (2011), Scrum is considered as a new agile project management methodology since it was first applied at Easel Corporation in 1993 by Ken Shcwaber, Jeff Sutherland, and Mike Beedle. Sliger (2011) adds that the Scrum idea basically was taken from a paper titled "The New New Product Development Game" written by Hirotaka Takeuchi and Ikujiro Nonaka in 1986 for Harvard Business Review where they used the concept of the rugby sport and how players work together, collaborating and forming circles to catch the ball and get it into the game again. As Sliger (2011) Stated, Later in 2002, the book "Agile Software Development with Scrum" was written by Schwaber and Beedle where they expressed in it their experience with Scrum. In 2004, Schwaber wrote his book "Agile Project Management with Scrum" which talks about his experience and his work with Primavera. In 2006, Jeff Sutherland founded "Scrum Inc.". Which states on its website (ScrumInc.Com) that it is an online authority on Scrum to provide coaching, training, consulting, and publish case studies, blogs, and scientific papers related to Scrum. As mentioned on its website, the Scrum Organization was founded by Ken Schwaber in 2009 to develop the projects within the software industry.

Referring to the above, it can be observed that Scrum is relatively a new project management methodology that has been mainly established and applied within the software projects industry and proved to be an effective methodology that found interest and developed through decades and eventually applied across many industries in recent years. Nowadays, there are global online organizations and institutes as the one mentioned above that give training and certify professionals in Scrum in many levels and positions. Later in this research, it will be illustrated if

Scrum can be applied to manage different phases of construction projects, instead of the traditional project management methodology, and if so how and where that can be applied.

2.1.2 Scrum Framework

This section will define all the components that make up the Scrum framework in detail and describe how this framework works, what are the major advantages and plus points of it, and how different it is from the traditional project management methodology.

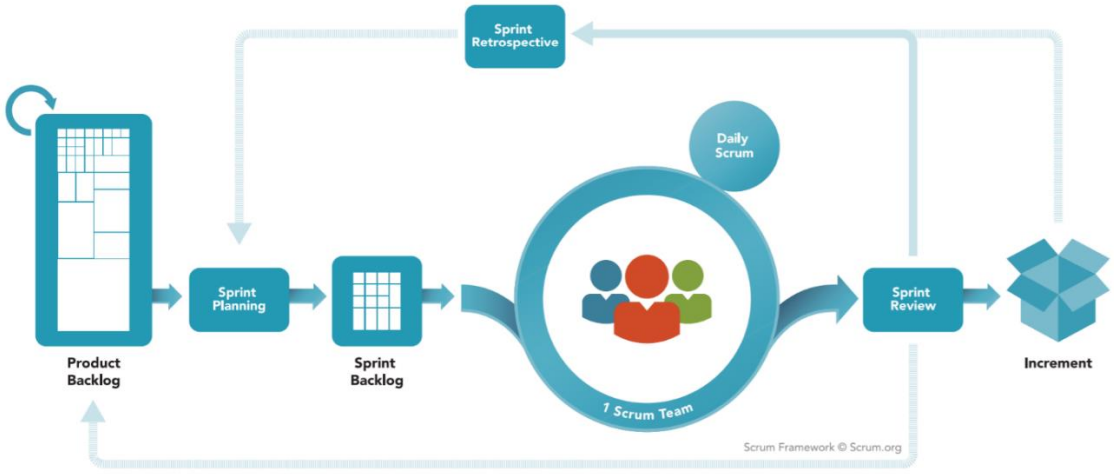

Figure (2). The Scrum Framework - (Scrum.Org)

The Scrum framework consists of two major elements, which are Events and Artifacts. With reference to figure (2), Scrum Events are as below:

a. Sprint
b. Sprint Planning
c. Daily Scrum

d. Sprint Review
e. Sprint Retrospective

The Scrum Events, according to (Rad & Turley 2013), are basically a time-boxed meetings that occur during Scrum workflow, have predefined agenda and objectives and lasts for a maximum of four weeks. These meetings are characterized by transparency and effectiveness and their focus is on the final product or sprint goal.

On the other hand, Scrum Artifacts are

a. Product Backlog
b. Sprint Backlog
c. Increment

According to (Rad & Turley 2013), basically the Scrum Artifacts are tangible and documented outcomes from the Scrum Events. Those outcomes aim to increase transparency amongst the Scrum team to facilitate inspection and adaption and ensure that all team members are on the same page and aware of the outcomes.

Below, a more in depth definition of each event and each artifact will be illustrated to have better understanding, analyze the framework and see how each component can be an added value in each of the five process groups that were mentioned in section (1.1)

Sprint: According to (Deemer, Benefield, Larman, & Vodde 2019), Sprints are iterations that occur within the Scrum framework. They are time-boxed up to a certain maximum of four weeks and usually are two weeks. Sprints go back to back which mean there no breaks between a sprint and next sprint. Regardless if a Sprint goal is achieved or not, a Sprint must end on a certain date

and it is not allowed to be extended, this is why beginners in Scrum are advised to take the maximum duration of Sprints so they avoid any delays or any conflict at work until they can have a better hold on their work. Sprints are incremental, which means it deliver tangible results in stages (Increment) until the whole product is ready and complete. The iterative nature of Scrum by having focused sprints that last maximum for four weeks can help by boosting the monitoring and controlling aspect among all other process groups. Also, having this iterative incremental nature assist the team in staying focused on certain scopes in each process, knowing that the sprint will end on a certain date that is relatively not far which motivates teams to accomplish the required work.

Sprint Planning: According to (Rubin 2018), Sprint planning is an event (meeting) that reoccurs at the beginning of each sprint, which mainly aims to decide what work will be done in that certain sprint. The length of this meeting depends on the length of each sprint, which may take between 2 to 8 hours (8 hours for a 4 weeks length sprint). The development team attends this event with the product owner to decide on the objective of the sprint (the sprint goal). According to (Schwaber & Sutherland 2017), Sprint planning discusses and answers to main topics, which are: what work will be done in this sprint (what is the sprint goal or the increment at the end of the sprint), and how will the required work to accomplish the increment be done?

Basically the development team decides, in coordination with the product owner, what is the sprint goal, which happens by selecting realistic items from the prioritized product backlog, where if these items are implemented and completed during the sprint the objective will be met. The product backlog and previous product increment is considered as the main input to the sprint planning. After selecting the most prioritized items from the product backlog that the development team believes it can be completed during the sprint, the development team then

starts analyzing how to complete these items or tasks to achieve the increment (sprint goal) at the end of the sprint. The development team establishes kind of a plan for the duration of the sprint on how to tackle and complete the selected backlog items to achieve the sprint goal. After this, the development team should be able to explain to the product owner and the Scrum Master what exactly it the Scrum goal and how the team is going to achieve this increment.

The Scrum Master role, in Sprint Planning, usually revolves around making sure that this event is flowing smoothly and with minimum conflict.

Sprint planning encourages team members who are going to perform the work to participate effectively and advise on what work can be done within a sprint's duration. Applying this in all process groups and especially in the design process where consultants have their own schedule to finish the design is extremely important. Each design team participates and selects, in coordination with the Product Owner, work that can be and must be done in that sprint in order to stay on track and avoid delays. Also selecting prioritized items and having it recorded in the sprint backlog, which is a result of the sprint planning meeting, keeps the team focused and not overwhelmed with too many tasks from the product backlog.

Daily Scrum: This event according to (Rubin 2013) is a time boxed meeting that usually does not exceed 15 minutes and happens on a daily basis during every sprint. The Scrum Master's role is to facilitate this event and make sure everyone in the development team understands the purpose of it since this meeting might be mistakenly taken as a status meeting which in reality is not. The main purpose of this meeting is to make sure that all development team members are on the same page, every team member has a clear idea of what he needs to achieve and for everyone to be informed of what has already been achieved. According to (Rubin 2013), basically in the

Daily Scrum three questions need to be highlighted and answered by every member in the development team, which are:

1. What did I achieve since the last daily Scrum?
2. What am I going to achieve by the next daily Scrum?
3. What are the challenges/conflicts that I faced or may face in accomplishing what I need to achieve?

Answering these questions creates a clear and transparent idea for everyone in the team about what have been achieved and what is left to be accomplished. Also it opens a brainstorming environment to share solutions and effective methodologies to accomplish better results and avoid delays.

From the above it can be observed that this meeting is an important event that needs to be conducted every day during the sprint and should not be misinterpreted as a daily status meeting since it is an outcome driven event and encourages better collaboration amongst team members in a transparent environment.

The daily Scrum meeting can be an added value in all processes but since it occurs on a daily basis until the end of every sprint, it can be specifically beneficial in the construction process because of the amount of activities that occur on a daily basis. Applying this meeting within the construction process not only benefits the Consultant's team, but can also keep the Contractor on track by notifying him of any delays or any possible delays that could affect the progress in the construction process.

Sprint Review: According to (Sutherland 2014), this is a meeting that takes place after every sprint to state what has been accomplished in the last sprint. This meeting can be attended by anyone such as the Scrum Master, development team, product owner, stakeholders,

customers…etc. According to (Sutherland 2014), in this meeting the development team shows and highlights what work/tasks has been completed and finished, even if it's not a final product, but a complete feature that meets the definition of 'done'. According to (Sutherland 2014), the Sprint review is considered as a great opportunity for communication to have a better understanding by everyone and especially the product owner and the development team of the market situation, the product itself, and requirements for next sprints. The duration of the Sprint review meeting depends on the Sprint's length. According to (Rad & Turley 2013), Sprint review meetings are 4-hour meetings for 4-week sprints and is shorter for shorter sprints.

This meeting specifically is extremely important since stakeholders and clients attend it and specifically the design and construction processes benefit from it. Involving clients and key stakeholders intensively, after each sprint (between one week to four weeks) in the design process, keeps them updated, their requirements and expectations understood, and allow for any changes to be done at the right time before commencing in more design work or construction work. The same applies for the construction process. As previously mentioned, the construction process contains enormous amounts of activities that need to be inspected and accepted before moving to the next works. Having clients involved in such a way in this process allows for them to check work performed by the contractor, inspect it, accept it or even make changes on it before proceeding to larger and more complicated work.

Sprint Retrospective: Referring to figure (2), the Sprint Retrospective is the last meeting that occurs after finishing a sprint and before starting a new sprint. The purpose of this meeting, according to (Sutherland 2014), is that "the team reflects on its own process. They inspect their behavior and take action to adapt it for future Sprints." Adopting this process can contribute to high positive results in next Sprints. (Sutherland 2014) claims that Sprint Retrospective meetings

should be facilitated and organized by the Scrum Master to be away from stressful situations and away from creating an unhealthy environment that focuses on blaming and dispute. (Sutherland 2014) Stresses that "psychological safety" should exist in this meeting among all team members to achieve the desired results from the meeting. Many things can hinder obtaining the psychological safety like having typical meetings that are rushed into finding solutions, abroad team members lack the face to face interaction needed for such meetings which may decrease the psychological safety, and having key organization members that are concerned with evaluation and increments can have a negative impact on this meeting as well.

It is highly recommended that the Scrum Master manage and facilitate the retrospective meeting, and start implementing the results and solutions that have been achieved by the team after they have resolved what can hinder gaining the required psychological safety to have better sprints in the future and have the desired final product or increments as a result of that.

This meeting acts as a meeting to document lessons learned and improve the overall process in general. This meeting can add value to all processes since it is always beneficial to avoid past mistakes and find ways to improve processes, but from a Consultant point of view, this process shines in the design and construction processes for the type of activities and work to be performed in both processes. This also is more effective than leaving the process of lessons learned until the closing phase and depending on team members' memory.

Product Backlog: The Product Backlog is defined by (Sutherland 2014) as a list of a product/project requirements (features), which are organized by the product owner based on its priority. Usually these features are detailed and not general features that are required to complete the project/product. As mentioned before, it's the Product Owner's responsibility to prepare this list.

The product backlog acts as a WBS (Work Breakdown Structure) that contains all work that needs to be done in each process.

Sprint Backlog: The Sprint Backlog can simply be defined as the output of the Sprint Planning event (meeting). Basically, according to Mastropasqua (2018), after having a prioritized product backlog from a product owner, the team selects what can be done through the sprint. The selected items and the plan to complete these items is the sprint backlog. The main purpose of the sprint backlog is to keep everyone within the development team focused and following the plan through the sprint.

The sprint backlog, acts as a focused WBS that has all the work to be completed within a certain sprint duration that could vary from one week to four weeks. This assists the project team, including the product owner, to focus and accomplish specific work without being distracted or overwhelmed with a large amount of work that could be in the product backlog.

Increment: As defined in (Schwaber & Sutherland 2017), "The Increment is the sum of all the Product Backlog items completed during a Sprint and the value of the increments of all previous Sprints." In other words, the increment is a portion of work that can be an added value towards the goal of the final product/project. Schwaber & Sutherland in The Scrum Guide 2017 stresses that to consider a work at the end of a sprint as an increment, it has to be something that can be inspected, usable, and meet the definition of 'Done' that is previously defined by the development team.

To further simplify, the meaning of an Increment is to recap the process from the beginning. After the development team selects the items from the product backlog that is going to be complete through a certain sprint and plan for it, during the sprint-planning meeting, it can get

documented in the sprint backlog. The team starts working on these items on a daily basis through the duration of the sprint and they attend a daily Scrum meeting until the sprint is done. After the sprint duration is done, a sprint review meeting is conducted to define what has been accomplished and complete from the selected items (features) and meets the definition of "Done" so it can be finally categorized as an Increment.

But what is the meaning of "Done"?

As defined by Meyer (2013), it's a checklist that needs to be prepared by the development team that has clear features, requirements, and characteristics of the product in order to be an increment. Mitchel (2017) demonstrates the importance of the definition of 'Done' and why it needs to be clear to all members within the development team as stated below:

1. Clear definition of 'done' and clear understanding of it from the development team contributes in bringing valuable work that can be inspected and used
2. Prevent losses in time and money due to rework from the development team
3. Keeps the development team focused and increases the transparency among the development team members of what needs to be achieved by the end of each sprint

From the above, it can be observed that the clear definition of 'done' among all members within the development team, even to the product owner, Scrum Master, and other key stakeholders, is extremely beneficial to achieve the desired product/project and will prevent the development team from falling into scope creep, rework, and other negative factors that may hinder accomplishing the core wanted results.

It is worth to mention an important tool usually utilized during sprints, which is the burndown chart. According to (Sutherland 2014), the burndown chart is a tool used to measure and

compare the amount of daily-performed work against planned work. It assists the team and product owner to stay on track day by day to deliver the desired product within the planned schedule. Figure (3) below shows a simple burndown chart where it demonstrates accomplished work against the planned within a certain Sprint. The burndown chart is daily monitored and discussed during the daily Scrum meeting.

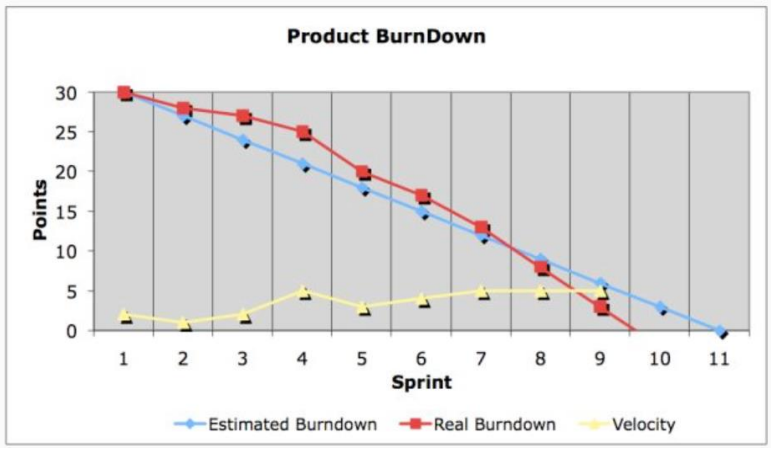

Figure (3): Burndown Chart (Scrum Institute 2018)

2.1.3 Scrum Roles

This section will highlight three specific Scrum roles (Scrum Master, Product Owner, and Development Team) in order to determine which of these three roles a Project Manager, under the traditional project management methodology, can practice as well as be fit best in terms of skills, knowledge, and experience. Below we will define the following:

1) Project Manager Role in the traditional Project Management methodology
2) Scrum Roles: Scrum Master, Product Owner and Development Team

Project Manager role: According to the (PMI 2013) and as defined in the PMBOK 5th edition, "The Project Manager is the person assigned by the performing organization to lead the team that is responsible for achieving the project objectives." This definition focuses on highlighting the Project Manager role within the project to meet a project's objectives taking in consideration the triple constraints (Scope, Time & Cost). On the other hand, (Duggal 2018) expanded the constraints to a diamond constraint, as shown in figure (4), which widens the meaning of meeting projects' objectives to reach out customer satisfaction and involvement and meeting the benefits of the organization and stakeholders' as well.

Figure (4). Diamond constraints – (Duggal 2018, P. 175)

(Duggal 2018) highlights that the meaning of project success includes meeting clients and stakeholders satisfaction, meeting the organization's business goals, and also accomplishing a project that is useful for the end user.

From an engineering consultant point of view, and when it comes to managing projects from initiation until closing including the construction process, things are a little different. Usually a Project Manager from the consultant side does not get deeply involved in the design phase and

the initiation phase, their main scope starts in the construction phase after design works are finalized. Their main role in the construction phase revolves around monitoring and controlling contractor's work, assuring quality, notifying the contractor and the client of any delays, avoiding changes and scope creep. After completing all construction works, a consultant Project Manager obtains acceptance from the client to start the closing process. The closing process includes testing and commissioning of all systems in the project, finalizing manuals and all documents of the project to hand it over to the client and obtain client acceptance on the overall project.

Regardless of the project size or the whole team size, Scrum roles get categorized into three roles, which are:

- Scrum Master
- Product Owner
- Development Team

1. **Scrum Master:** The Scrum Master's role may not be the traditional role of Project Managers since Scrum is not the same as the traditional management methodology. Verheyen (2014) claims that the Scrum Master is "accountable for the understanding and application of Scrum."

   According to a recent paper (Noll *et al* 2017), the Scrum Master's role is to facilitate and smoothen the process of developing a product/project and that the entire development team have clear understanding of Scrum and how it works, removes any conflict that the team may encounter and conduct the daily Scrum meetings, serves and provides coaching for the development team.

From the above it can be observed that the main role of the Scrum Master is to lead the development team towards sound Scrum practices and ensure a smooth process by coaching and eliminating conflicts that may appear within the team or from the outside. When it comes to managing projects from a consultant point of view, the Scrum Master role can be practiced by a nominated team leader that has great communication skills, technically strong, and has experience and knowledge in Scrum to be able to assist and coach the development team. This team leader can act as a product owner assistant through the life cycle of a project from initiation until closing of the project.

2. **Product Owner:** A review by Sverrisdottir et al. (2014) highlights that the product owner is one person, not a group of people, that represents all other key stakeholders and he is the one responsible for financing the product/project, and defining the needed work within the project as he is responsible for maintaining the product backlog, updating it, and prioritizing the items in it. The product owner puts the objectives and the requirements of the product/project, takes decisions as necessary, and he is responsible for the product/project success.

   Sverrisdottir et al. (2014) States that the product owner provides the team with the necessary advice and support without applying any authority on the team as in the same time he needs to work close to it.

   It may seem the that the product owner has a similar role to the client or sponsor role in the traditional management methodology, but it differs since a product owner is involved more in his product/project and can intervene faster than usual than a client and have more contact with the team as he always prioritizes for the team what work needs to be completed, which may seem similar to the traditional Project Manager role as he is the

one responsible for the project success but on the other hand does not finance the project/product.

Practicing Scrum necessarily needs special training and experience within Scrum and the agile methodology. Usually the practitioners of the traditional project management methodology, especially Project Managers, have misunderstandings or conflict when it comes to adopting Scrum roles.

According to (Noll *et al* 2017), Scrum Masters can create conflict by adopting the Project Manager role with other responsibilities, where it is suggested that traditional Project Managers become Product Owners, as this role is more compatible with the role of traditional Project Managers. Cornelius (2014), claims that based on the PMI definition of the Project Manager role, a modification in his role within the agile methodology will create conflict and challenges.

The product owner role in Scrum may not be the perfect fit to be filled by Project Managers, but based on their experience and technical skills along with practice in the traditional project management methodology, it is better for traditional Project Managers to practice the role of product owners than practicing the role of Scrum Master. Product owners take decisions, have crystal clear understanding of the product/project scope, represent all key stakeholders, deal closely with all other team members and are responsible for the success of the project/product. The only thing that will be excluded from Project Managers' role when they practice product owner roles in Scrum is financing product/project, which means that a Project Manager, with proper introduction, experience and training in Scrum, will be a good fit as a product owner except for financing a project which will be done by clients as usual in the construction industry.

Project Managers when practicing Scrum and adopting the product owner role will be in deeper involvement in the project itself from initiation until closing, and will be in close contact with clients which will increase their understanding of clients' requirements and expectations which will result in less changes from clients, avoiding delays and rework.

3. **Development Team:** The development team is the team who builds the product/project. (Diebold *et al* 2015) Claims that the development team usually consists of members who work collaboratively to achieve the same goal (increment) and usually its members vary between three to nine members.

   (Diebold *et al* 2015) Explains that the members of the development team have different levels of experience and work autonomously. (Sutherland 2014) highlights that the whole development team is accountable for the work regardless of individual achievements and skills.

   The development team works close to the product owner, as the work is based on items selected from the product backlog. They work individually and transparently through different events (meetings) that were defined before, which create a healthy transparent, and productive environment.

   The development team in engineering projects varies depending on the process. For example, the design team is usually different than the construction team which is located on a construction site to monitor and control Contractors' work. While practicing Scrum, the Product Owner can acquire the necessary team based on the process in coordination with the upper management of his organization and other running projects. The

development team in Scrum, same as traditionally managed projects, need to be technically strong, experienced in his field, and reliable to accomplish results on time.

2.1.4 Conclusion:

Construction projects go through different phases and therefore require experienced Project Managers and experienced teams to manage and run these phases. Consultants' Project Managers are experienced professionals that are responsible for a project's success or failures, aware of project requirements, technical work that needs to be performed by Contractors and in close contact with Clients therefore, adopting the Product Owner role when practicing Scrum will not create conflict and will be compatible with their skills and experience. Project Managers will practice the role of Product Owners except financing projects, and within the Scrum methodology they will be in contact with clients more often. Scrum Masters role revolves around ensuring the smooth practice of Scrum by team members and therefore a Scrum Master can be a senior team member assigned by the Product Owner to supervise and monitor the team practicing Scrum and coach them as necessary.

2.2 Current Status of Scrum in the Construction Industry in General

Before examining the application of Scrum within the five processes that are managed by consultants in order to deliver a full (complete) project, first let us understand the general current status of Scrum in the construction industry.

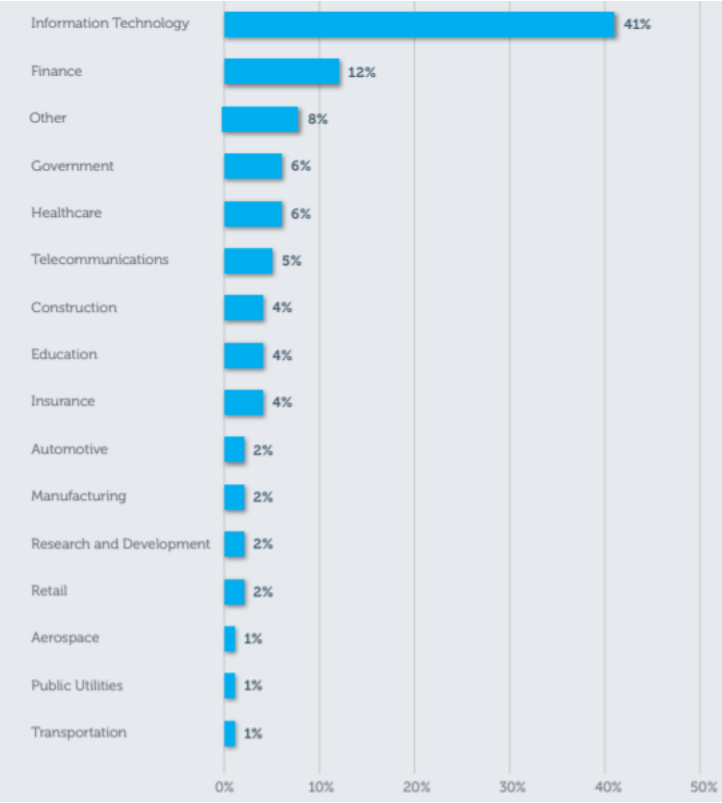

Figure (5): Scrum usage in various industries. (The 2015 State of Scrum Report)

Referring to figure (5), it can be observed that Scrum usage within the construction industry, in general, is quiet low and limited.

The Construction Industry in general is considered a conservative industry that typically does not accept changes easily and it rather takes a while to apply new methodologies or even

technologies. For decades, the traditional project management methodology was the main methodology to manage construction projects and other phases prior and after construction. As discussed in this section (traditional project management methodology), the traditional sequential methodology may not be always the ideal methodology to manage construction projects, or other phase's pre or post the construction phase. The traditional methodology can be replaced or combined with other methodologies to facilitate managing different phases.

2.3 Utilization of Scrum in The Five Process Groups

This section will examine the utilization of the Scrum framework only in the five phases (process groups) that are traditionally followed to deliver a final result/project which are Initiation, (Design) Planning, Construction (Execution), Monitoring and controlling, and Closing from an engineering consultant point of view. Any process out of the project boundaries will not be the focus of this research. According to the (PMI 2013), the project feasibility and business case study is handled, finalized, and approved before commencing in the initiation process (out of the project boundaries). Figure (6). Shows project boundaries.

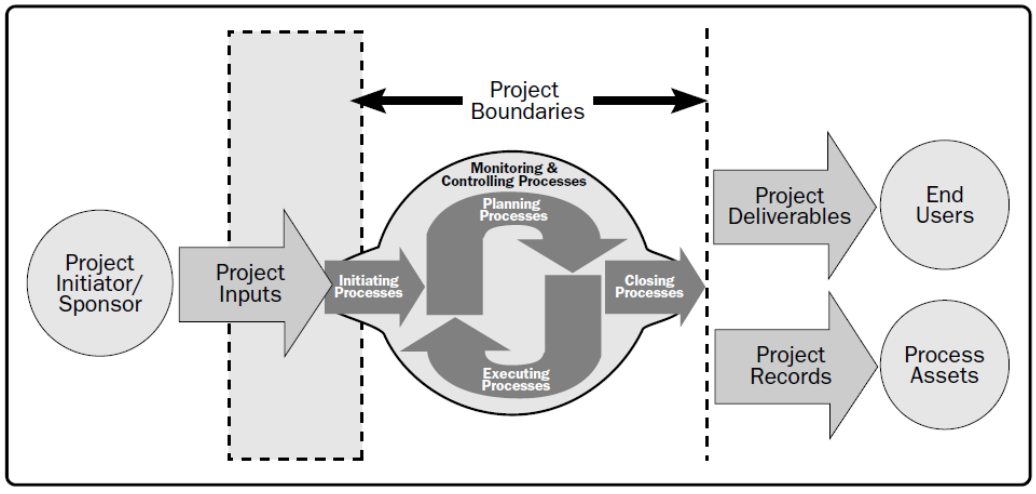

Figure (6). Project Boundaries (PMBOK 2013, P. 53)

2.4 Utilization of Scrum in The Initiation Process

According to the (PMI 2013), "The Initiating Process Group consists of those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase." (PMI 2013) clarifies that this process mainly aims to create a clear vision of the project and what work needs to be accomplished. The two main outputs of this process are the project charter and the stakeholder register.

The project charter is the official document issued and signed by the sponsor (The client himself or a representative) that states the approval of the project. The project charter contains the name of the assigned Project Manager for the project and his level of authority. Also, highlights on a high level without much detail, objectives of the project, a justification why this project is needed, possible risks and constraints, project budget, duration of the project, success criteria, summary of milestones, high level requirements, and the main stakeholders.

The stakeholder register is a document that can be modified during the time of the project as stakeholder's leave and join. It additional lists information about the stakeholders, their level of interest, their level of involvement, their major expectations, and their level of support towards the project.

Although the PMBOK encourages Project Managers to have a role and participate in the development of the project charter, The (PMI 2013) states that it is significantly the project sponsor's role to develop the project charter and specify the Project' Manager authority in it. On the other hand, Brown (2005), claims that many Project Managers accept minimal roles in developing a project charter, where they need to be more involved in this process and recognize

the importance of it to deliver an adequate charter especially if the sponsor does not deliver one or not capable of developing one.

The Project Manager needs to be involved in the development of the project charter to have better understanding of the project, project's constrains, key stakeholders, and have a basic foundation that assists in the planning phase and in developing the stakeholder register as well. By applying Scrum in the initiation process Project Managers will become Product Owners where they need to develop a product backlog of work to be done which allows them to go through the components of the project charter and stakeholder register along with the client/sponsor at this phase and participate in developing them while having close contact with the client, sponsors, and any other key stakeholders.

Also, Scrum requires client's involvement in this phase from collecting requirements until accomplishing the final product. The product in this process will be both the project charter and the stakeholder's register. According to (Owen *et al* 2006), any detailed planning in the pre-design phase is considered inefficient and null due to the uncertainties and detailing in this process/phase. Also (Owen *et al* 2006) stresses that a client's involvement in this phase is highly advantageous especially if it is developing the product in an incremental and iterative way. (Owen *et al* 2006) Argues that the nature of the agile methodologies offers potential improvements in the pre-design phase because of the structured but still enough flexible to come up with solutions and opportunities.

Clients' deep involvement in this phase is significant and beneficial for both the product owner and the client himself where they get to know each other very well, have solid understanding of the project nature and have clear clients' requirements prior to the design phase.

2.4.1 Mechanism of Scrum within the initiation process (Pre-Design)

Scrum framework starts with the product backlog, which needs to be prepared by the product owner. As explained earlier, the product owner's role is best to be practiced by a traditional Project Manager for what it represents as a critical role. The PMBOK highly recommends that Project Managers get hired and designated early on in their projects. The product owner in this process (which is originally a Project Manager) will be in high contact with the client in order to collect all the high level requirements, understand the client's vision and clear understanding of his project which will require having a proper backlog for each process and each product (Outcome). The following points will present an example of how to run this process:

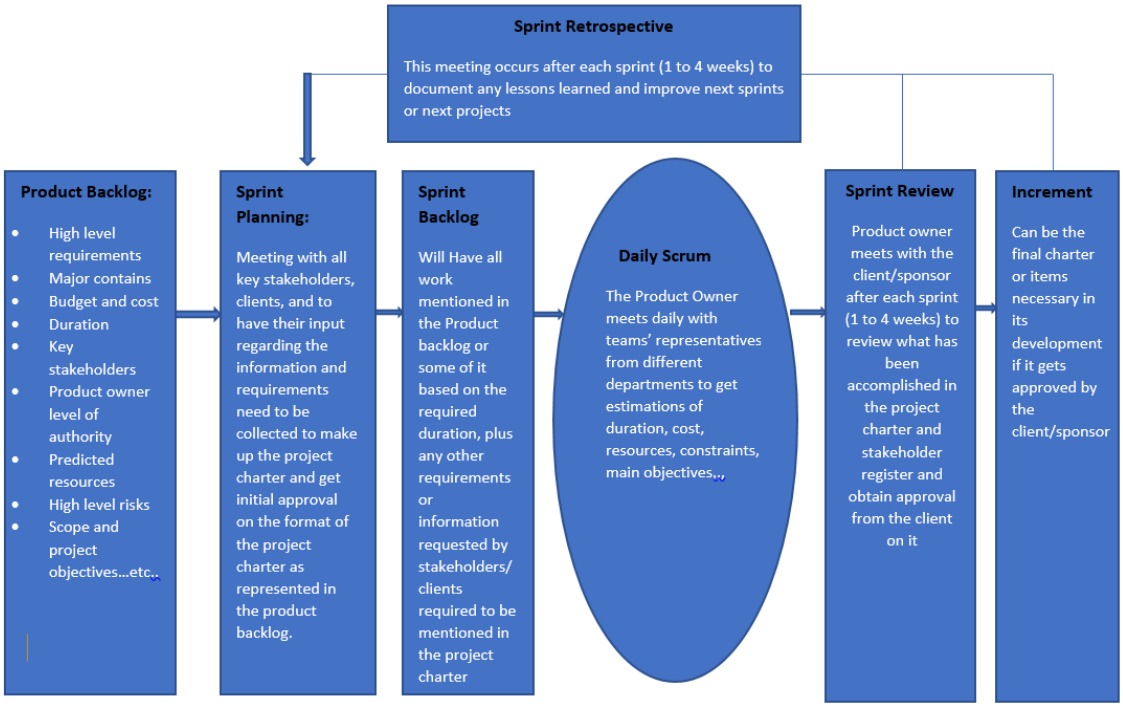

Figure (7). Utilization of Scrum in The Initiation Process Group – Project Charter Case

1. In order to have a proper project charter there are inputs that need to be obtained such as estimation of cost and time, high level requirements, high level risks, product owner level

of authority and much more. All of these items make up the project charter and the detailed work required to obtain these items need to be documented in the product backlog.

2. Since the project charter is not required to be detailed, it can be done basically by the product owner himself in a coordination with other teams that will be participated in the future like construction team and the design team and any other teams. Also clients' presence and any other key stakeholders is required at this stage to collect any high level key requirements and constraints from their side. After creating the product backlog, which include items and information need to be obtained to make up the charter, a sprint planning meeting will be conducted by the product owner with all key stakeholders, clients only to collect all requirements and as much possible of information to have it in the charter.
3. The output of the sprint-planning meeting will be the sprint backlog, which based on it the sprint duration at this stage will be determined by the product owner since not much effort is required from other teams. The sprint backlog at this stage will include mainly work to be done and information to be gathered by the product owner and other team's representatives.
4. During the sprint, a daily Scrum meeting is conducted with representatives of different departments to assist the product owner in identifying requirements, constraints and estimations. It is advisable at this stage that the product owner himself attend this meeting instead of a Scrum Master to make sure that requirements are understood, work flows smoothly and no delays will occur

5. After completing the sprint duration (which can take anywhere between one week to four weeks) an important meeting gets conducted which is the sprint review. In this stage the sprint review meeting will be conducted to review the project charter that was created by the Product Owner in a coordination and continuous communication between him and key stakeholders, clients and different team members. At this stage only the Product Owner and other key stakeholders/clients attend this meeting. If the charter is complete and product owner authority level is specified, the sponsor/client can sign it off to officially start the project so the product owner and his team can move to the next process, or in case of any required changes it can go for another sprint to finalize the charter.

Before commencing in a new sprint or moving to the design process, it's essential that the Product Owner conducts and attends the sprint retrospective meeting (Capturing and Documenting Lessons Learned) in order to steer his and himself team to be more effective in following sprints or other projects and avoid any faults/shortages that might have occurred in the previous sprint. This meeting, at this stage, will add value in this process and following processes, especially when activities increase and get complex in the execution, monitoring, and controlling phase and can even add value to future project

In this stage the Product Owner's responsibilities and tasks will be as below:

1. Prepare a detailed product backlog of all information needs to be in the project charter along with work required to obtain it.
2. Leading the sprint planning meeting and deciding on the sprint duration

3. Attending the daily scrum meeting with team's representatives and documenting its results
4. attending the sprint review meeting with the client and key stakeholders
5. Conducting lesson learned meeting (Retrospective meeting) to

2.4.2 Conclusion

Product Owner's and clients intense involvement is necessary in the initiation phase and cannot be skipped for what it results in and represents. Product Owners needs to work early on with clients and any other key stakeholders to have a solid grip on the project's objectives and its clients' requirements, know stakeholders' level of involvement and influence on the project, and at the same time for stakeholders to know more about their project which assists them in forming their requirements and supporting the project.

2.5 Utilization of Scrum in The Design Process

This section will demonstrate how can Scrum be utilized in the design process of construction projects and how that utilization will beneficial to all parties that participate in design process and enhance the quality of design works in terms of having comprehensive design that is well understood from the consultant's team and the client as well, which leads to less changes in the construction process.

For consultants, the design phase in many projects is considered a critical phase since contractors just take designs from consultants and execute based on that. In the design phase, consultants study a project and all its elements (Architectural, Structural, and MEP) in order to bring something useful and add values on blueprints.

Traditionally consultants understand a client's requirements and come up with a design based on that. But even designing a project after collecting client's requirements does not always lead to perfect results immediately because there is a gap between collecting and understanding requirements and completing the design which results in rework in order to meet a client's desire(s). According to Wideman (1981), most of clients are not aware of how much time consuming it can be to do any changes to a complete design. According to (Yang & Wei 2010), most delays occur in the design phase because of clients' changing requirements.

From another angle, waiting until the whole design is complete without a clear end date, for this phase, leads to delays which may have major cost implications on both Consultants and Clients. Jin (2017) claims in his research that a huge part of the success of any construction project has to do with the design process.

From the above it can be observed that an effective solution needs to be applied and followed to avoid rework, delays, and changes in designs especially during the construction phase.

Although Jin (2017) states that utilizing agile methodologies in the design phase by Project Managers still cannot be considered effective and faces many challenges and obstacles due to limited knowledge of these methodologies, Liu (2018), in his research, claims that applying Scrum framework in the design phase makes the design process smoother and more effective because of clients' early involvement that brings higher customer satisfaction. Also Liu (2018) claims that applying Scrum within the design phase improves the performance of all team members since every team member feels a certain level of responsibility to perform better in a healthy work environment where transparency exists amongst all team members, which will result in having better deliverables. According to a review by Streule et al. 2016, applying Scrum in the design phase prior construction will fasten the process of design and make it more

effective. A recent paper by (Theis *et al* 2016), states that the waterfall methodology is great in representing critical path and to check the effectiveness of a schedule but when it comes to a dynamic process with high uncertainty like the design process, superior integration and collaboration is required which can be accomplished by utilizing agile methodologies that can adapt fast to changes applying requirements.

Even though Scrum and agile methodologies in general are still a new trend, especially to a conservative industry such as the construction industry, many professionals around the world believe that applying these methodologies in construction projects could bring potential value, especially in the design process which represent the foundation of construction works on ground.

2.5.1 Before the Design Process

Before commencing in any design works, the Product Owner needs to deeply collect requirements from the client and any other key stakeholders, which will be the basis of any design. As defined in the PMBOK, "Collect Requirements is the process of determining, documenting, and managing stakeholder needs and requirements to meet project objectives." The same requirements will shape the foundation of the product backlog, which needs to be prepared by the Product Owner

Figure (8) shows the inputs, techniques, and outputs of the collect requirements process. Techniques used in this process are many but what best fits the Scrum framework are interviews with the client and key stakeholders or having focus groups. The Product Owner is the one who decides which technique between these two to practice depending on the available time and number of stakeholders.

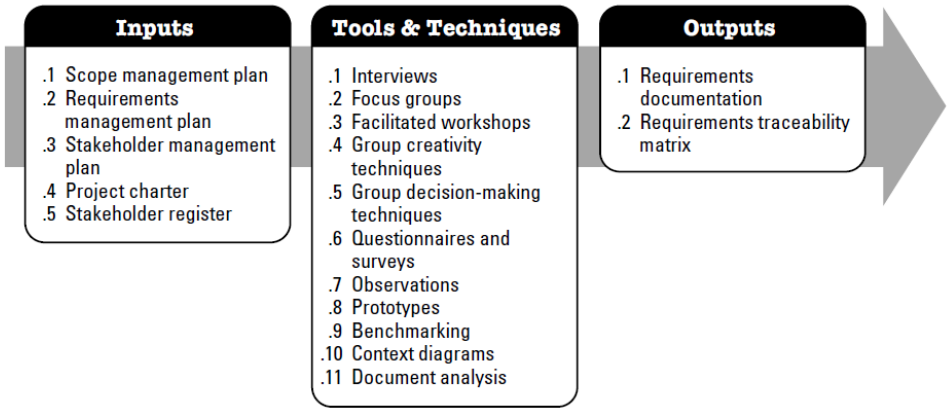

Figure (8). Collect Requirements: Inputs, Tools & Techniques, and Outputs (PMBOK 5th edn, P.110)

The inputs to this process, as shown in figure (8), are Scope management plan, Requirements management plan, Stakeholder management plan, Project charter, and Stakeholder register. The project charter and stakeholder, as mentioned earlier in the (initiation phase section) are available from the initiation phase and can be developed and obtained using Scrum framework. According to the (PMI 2013). The scope management plan, requirements management plan, and stakeholder management plan are defined as below:

Scope management plan: Plan that assists the project team on what type of requirements are needed to be collected for the project

Requirements management plan: Plan that explains the procedure of collecting and documenting stakeholder requirements for a project

Stakeholder management plan: Plan shows and assist in understanding how to communicate with stakeholders and what is their level of participation in collecting requirements and identify the key stakeholders.

By practicing Scrum, the three previous plans can be internally understood and followed without having them officially in hand. The Product Owner by his experience can determine the type of requirements needed to be collected in this stage (Scope management), and can deal and meet with the necessary and key stakeholders to collect their input and requirements (Stakeholder management), and then documenting these requirements in the product backlog as work needs to be done and achieved by the end of each sprint until the full design is complete (Requirements management).

The outputs of the collect requirements process as per figure (8), are requirements documentation which is a document that shows how each requirement meets that final project's objectives and can vary from high level requirements to very detailed one. Type of requirements can be business requirements, Stakeholder special requirements, project requirements, constraints, etc. The other output which best matches the product backlog in Scrum is the requirements traceability matrix. According to the (PMI 2013). The requirements traceability matrix is a grid that connects the original requirements to their final deliverables that make them complete and accomplished. According to the (PMI 2013) applying this matrix ensures that each requirement is a valuable requirement and goes hand in hand with the project final goals. Also, this matrix helps in tracking all approved requirements by all stakeholders and that they were achieved by the end of the project, which also helps in avoiding scope creep and assist in any necessary changes in the scope. Figure (9) shows an example of a requirements traceability matrix Documenting all approved requirements in the product backlog along with scope of work (All work needs to be done in the design process) is similar to what the requirements traceability matrix does. This ensures achieving comprehensive design and avoid wasting time and effort in

the Requirements Documentation since all information of this output will be already part of the product backlog.

Requirements Traceability Matrix								
Project Name:								
Cost Center:								
Project Description:								
ID	Associate ID	Requirements Description	Business Needs, Opportunities, Goals, Objectives	Project Objectives	WBS Deliverables	Product Design	Product Development	Test Cases
001	1.0							
	1.1							
	1.2							
	1.2.1							
002	2.0							
	2.1							
	2.1.1							
003	3.0							
	3.1							
	3.2							
004	4.0							
005	5.0							

Figure (9) Example of a Requirements Traceability Matrix. (PMBOK 5th edn, P. 118)

2.5.2 Scrum Mechanism in The Design Process

The Product Owner can determine the final date of accomplishing the full design of the project and having it on hand based on the previously documented requirements and complexity of the design. The full design can be divided into three segments, Architectural, Structural, and MEP (Mechanical and Electrical). This division makes having clear end dates for each segment more realistic and clearer than waiting for each team to finish and hand its part to other parties. Also, managing smaller teams is always better, leads to better results and make each group focus on its specialty.

The Product Owner can divide each design category to certain number of sprints depending on the type, size and quality of the project.

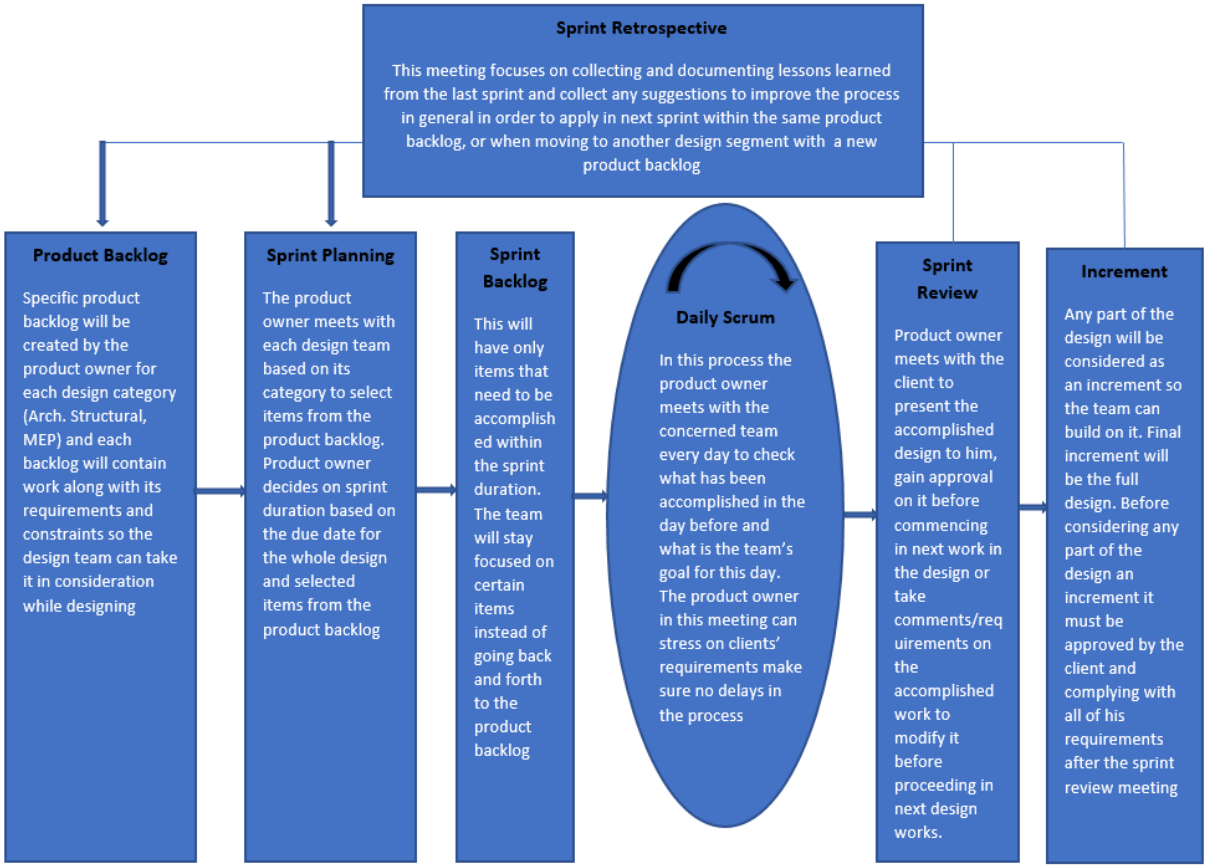

Figure (10). Scrum Framework in the Design Phase

Figure (10) shows the flow of Scrum framework in the design phase. After preparing the product backlog by the Product Owner for a certain segment (Structural, Architectural or MEP) the Product Owner conducts a sprint planning meeting with the concerned design team to select items from the product backlog in order to design it and prepare it for the client. Sprint duration will be decided by the Product Owner based on the quantity of selected items and an agreement with the client. The sprint backlog will contain only items meant to be done in this current sprint in so the team can focus on it and avoid being distracted. After that, the team commences in the design works with having a daily Scrum meeting, since this process is has a lot to do with

clients' requirements and possible changes in the design, the daily Scrum meeting will be conducted by the Product Owner and not Scrum Master at this process to make sure that clients' requirements are applied and any comments from the clients on any part of the design are understood and applicable. At the end of a certain sprint a sprint review meeting will be conducted in the presence of the Product Owner and the clients with all other key stakeholders to decide on the accomplished work and if it meets the requirements or not that was collected in the product backlog. If the design satisfies the clients' requirements it will be considered as an increment and the team will move to another design segment or another part of the same segment to complete the design.

After each sprint, it is recommended that the Product Owner conduct a sprint retrospective meeting to address any issue that might have happened in the past sprint and records lessons learned instead of waiting until the end of the project or end of phase as usually practiced in the traditional methodology where documenting lessons learned occurs in the closure process of a project or certain phase of a project.

Through sprints, the Product Owner will lead his team to finish all the design works for the project while having each portion of the design inspected and approved which will result in having a fully approved design that is well understood from all key stakeholders that meet their desires, requirements, and their expectations.

The responsibilities of the Product Owner (Project Manager) in the design phase will be:

1. Collect all requirements that are related to the design process directly or indirectly from clients and key stakeholders
2. Create a proper product backlog for each design segment that coordinates with stakeholders requirements

3. Assign team members for each design segment
4. Conduct a sprint planning, daily Scrum, and sprint review meetings with the related team members until the end of each sprint in a coordination with all related stakeholders
5. Conduct a sprint retrospective meeting at the end of each sprint to document lessons learned and improve the next sprint/project experience

2.5.3 Conclusion

The design process for engineering consultants is considered one of the most, if not the most, important process groups since it is their main scope to come up with a comprehensive design that is free from flaws, well-coordinated and most importantly meets clients' requirements and expectations. Therefore, having solid and successful design by the consultant is translated by having zero or the minimum changes on the design by clients within the construction process. Also, having flaws or miscoordination in the design that leads to delays when changing the design or raising Request For Information by contractors to the consultant is an extremely important point for consultants that they always thrive to avoid. Having focused requirements traceability matrix represented by having focused product backlog can be enough for consultant in this process instead of spending time and efforts form resources in creating stakeholder management plan or scope management plan where with Scrum the client can directly participate and work closely with the Product Owner to have this input in this critical process to apply any necessary changes instead of applying it in the construction process where it will result in delays, rework, and cost overrun.

2.6 Scrum within Execution and monitoring and controlling processes

Consultants' scope in the execution phase is completely different than contractors' scope. Contractors' scope in this phase in most projects tends to be bigger than a consultants' scope since basically they are builders who apply the design from a consultant to be a tangible reality on site.

According to Straçusser (2015), agile methodologies and principles have been adopted in the execution process by a contractor of an RD&D program related to uranium enrichment technology that included building, operating and testing machine cascades and commercial plant systems in Ohio, USA resulted in completing the project under budget, on time, and without having any safety issues nor deficiencies.

This case is an example of utilizing agile in the construction process by a contractor while this section will discuss the utilization of agile, specifically Scrum, within the execution process by consultants.

A review by Streule et al. (2016) stresses that apart from the design phase, Scrum can be applied in the construction phase and the daily Scrum meeting can add value to the construction process. Consultants usually are representatives of clients on construction sites; therefore, they have to ensure that contractors are doing the right work as per stakeholders collected requirements. Figure (11) below, shows the processes under each process group. Perform quality assurance is the process where consultants usually focus on in this phase. As defined in the PMBOK 5th edition "Perform Quality Assurance is the process of auditing the quality requirements and the results from quality control measurements to ensure that appropriate quality standards and operational definitions are used." The quality control measurements can be defined as

benchmarks to assess the quality of performed works against organization standards, which also can be stakeholders' requirements. Those measurements are a result of control quality process. Control quality is a process under the monitoring and controlling process group that is concerned with monitoring and measuring the results of activities carried out in the execution process. The key benefits of this process according to the PMBOK 5th edition are:

a. Determine causes of flaws and poor quality of a certain deliverable or product and eliminate them
b. Make sure that final deliverables and performed work on site meet collected stakeholders requirements that are a must for final approval and project acceptance

The two process groups (Execution and Monitoring and Controlling) will be merged in order to properly understand the whole process and role of consultants on construction sites. Also as shown in figure (6), the monitoring and controlling process is happening in parallel with all other process groups. Another reason of merging these two processes together is that a tremendous amount of activities happen daily on construction sites that accordingly need to be managed, monitored and controlled on a daily basis if not on an hourly basis in some phases within the construction process.

Traditionally, consultants used to take a certain path in managing the construction process where different phases occur and tremendous amount of activities occur within each phase every day, which make proceeding with next activities/phases critical since the performed work by contractors needs to be accepted and meet stakeholders requirements. As known, the quality assurance/quality control process on construction sites starts with contractors raising inspection requests to consultants to check the performed work. Taking in consideration the amount of

activities and work carried out on construction sites every day, the traditional methodology of managing and monitoring and controlling this process has risks and shortages as below:

1. The performed work by contractors on site may not meet stakeholders' requirements and desires which will result in rework, delays, and extra cost
2. With the amount of activities carried out on site, many activities and elements can pass without being inspected
3. Stakeholders are not involved in the inspection/acceptance of works process may lead to change orders/change requirements in the future which may lead to delays and overcast

Therefore, a new methodology is needed in order to resolve this shortage in the traditional methodology to reach a higher quality of performed work, avoid delays and extra costs and most important meet the stakeholder's requirements which is the soul of Scrum.

This section will show the application of Scrum in the construction (Execution) process and monitoring and controlling process to improve the quality assurance and quality control process plus highlighting how can consultants benefit from Scrum's framework in managing projects' baselines like schedule baseline and monitoring and controlling risks.

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

Figure (11) Project Management Process Group and Knowledge Area Mapping-

(PMBOK 5th edn, P. 60)

2.6.1 Mechanism of Scrum to control quality during the construction process

As known, during the construction process, projects go through different phases like piling and shoring, substructure, superstructure, finishing, handing over, etc. and in these phases different activities occur every day and every hour. Therefore, the best way to manage quality of these works and keep proper record of it is to divide those phases and have clear guidelines and quality control measurements for all major activities within each phase. In the simple Scrum framework the start again will be from the product backlog which will contain here the below:

a. Main activities and complete works to be monitored and inspected
b. Guidelines and success criteria for each work
c. Checklists for each complete work

The product backlog will be prepared by the Product Owner including the above three components. The performing team in this process is different than the design team. Usually the team here consists of site engineers that report to the Product Owner). The rhythm of work under Scrum framework will be as below

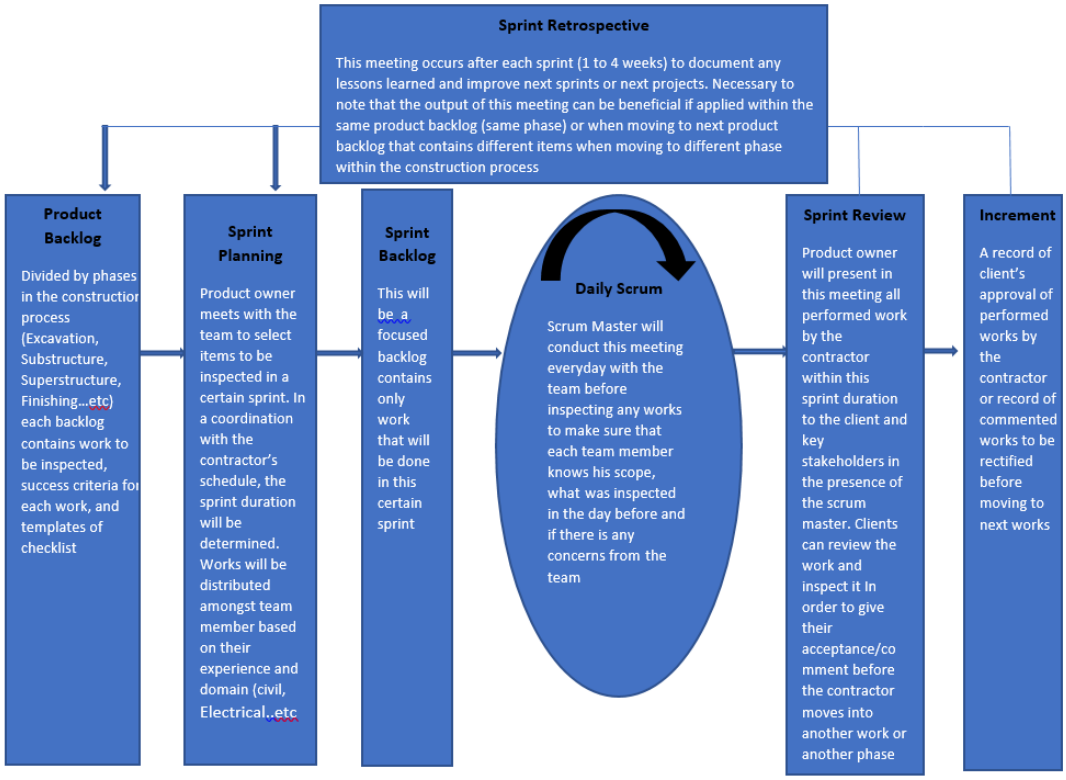

Figure (12). Scrum Framework in the Construction Process

1. A product backlog gets prepared by Product Owner. Templates, checklists, and guidelines can be provided by the headquarters or the project management office (PMO) to support and facilitate this process. A separate product backlog will be prepared for each phase within the construction process
2. The Product Owner needs to set the time for each sprint. Usually schedule for the construction process is prepared by the contractor and approved by the consultant/client prior to commencing in this process and set as a baseline. The consultant on site needs to follow the contractor's approved schedule in terms of planned work and timeframe for each activity/phase. Based on the schedule baseline the Product Owner will set the duration for each sprint to monitor and inspect complete works. This will allow for a

proper record of all complete works and will assure that each complete phase is accepted by the client/ consultant as will be explained in following steps

3. A sprint-planning meeting will be conducted by the Product Owner in the presence of his team to select the items that will be inspected. It is advisable in this process to keep each sprint's duration at one week only, especially at the beginning of the construction process, in order to better understand the logistics of the construction site and normalize the interaction between team members. After the team selects the items to be inspected for a certain week in coordination with the Product Owner the sprint backlog will be ready.
4. Before commencing in any inspection works, the team will have a meeting in the morning (Daily Scrum) with the Scrum Master to verify which items will be inspected, what has been inspected in the day before, and to raise any concerns about quality issues or accepted tolerances. The Scrum Master in this process is an experienced personnel that is assigned by the Product Owner to monitor the process of quality control, and lead the team to achieve the best results.
5. After the team conducts inspections on site, it is advisable if monitoring on works during the day remains constant on hourly basis to ensure that works are properly performed. Inspections on site will be usually conducted in the presence of contractor's representative. The team members will fill the checklist and properly record it so it can be discussed in the sprint review meeting. If the team faces any issues they can report back to the Product Owner that is usually full time on site.
6. After completing the sprint, a sprint review will be conducted to verify and record all work that has been done by the contractor and inspected by the consultant during the last

sprint. Here, the client attends this meeting in order to give his clear acceptance of the performed work. If the work is not an interest of any stakeholder or stakeholders do not have enough knowledge related to the performed work and the work is already inspected by the team, the Product Owner can accept it to move on to next sprint and consider the accepted work as an increment

As practiced in other processes, a retrospective meeting can be conducted to document lessons learned and to discuss with the team if there was any difficulties or conflicts in the past sprint to avoid it in next sprints and to improve the process as a whole. The retrospective meeting can be really valuable where it assists the Product Owner and his team to avoid mistakes in short and long term. The retrospective meeting can be conducted after the sprint review meeting and its output can be applied on the same product backlog (while selecting items in the sprint planning) or while creating new product backlog for another phase within the construction process to improve the overall process and any future projects.

Although the focus of engineering consultants within the construction phase focuses on quality of performed work by the contractor, many consultants have wider scope of work within the same phase that includes monitoring and controlling project's baselines and monitoring and controlling risks.

2.6.2 The Dynamic Nature of Scrum in Responding to Risks and Client's Changes

This section will demonstrate how the dynamic nature of Scrum will have a positive impact on a construction project whereas the focus will be on risks that are generated by the Client and Contractor. This section will highlight the positive impact of Scrum in managing and decreasing client related changes and changes in client requirements within the construction and design processes that usually affect projects' baselines negatively.

As explained earlier in this paper, the agile project management methodologies and particularly Scrum, are still facing resistance and some challenges from many professionals involved in construction projects management. A recent paper by (Collyer *et al* 2010), states that that many professionals in managing construction projects do not embrace changes and resist changes as much as possible and believe that the static traditional project management methodology is the best methodology to manage construction projects.

While many Project Managers may not believe in the dynamic nature of construction projects and try to resist changes and avoid it by sticking to the traditional project management methodologies to have limited client intervention and just focus on uncontrolled risks, many other started paying attention to what can really cause major negative impacts to a project's scope, time and cost.

Liu (2018), highlights in his research that agile methodologies support and facilitate the dynamic nature of construction projects. Although the PMBOK represents the traditional project management methodology which is static in nature, it still stresses on the term "Progressive Elaboration" as a necessary process throughout any project's life cycle. This term means that the

project plan needs to go through many changes and many detailing as the project progresses and becomes more complex. Construction projects and specifically in the construction phase go through many challenges and different changes and risks, which require dynamic and light response to these changes.

Most Consultant's Project Managers focus on changes and deviations from scope that are generated from contractors and think of risk sources as if they are only from Contractors. Choma (2008) states that having Contractors in construction projects significantly increases the risks within the construction such as delays, exceeding budgets, low quality of works, accidents on construction sites and many other. While these risks exist within the construction (execution) phase, the dynamic nature of Scrum that is represented by daily Scrum meetings, sprint review meetings, deep clients' involvement, and focusing on getting items inspected one by one during the construction phase can control and limit contractor's generated risks up to a high level, but contractors are not the only source of risks in construction sites. Clients in construction projects bring a lot of serious risks to the table. According to Jarkas & Haupt (2015), in the construction process, most serious risks are client related. A study by (Hwang et al 2014), found that rework related to or initiated by clients occurred in above 59% of complex projects which led to almost extra 7% in cost and 3 weeks of delays. The PMBOK basically classify stakeholders to Unaware, Resistant, Natural, Supportive, and Leading. When it comes to key stakeholders such as clients it is vital to have them on the supportive and leading side in order to have a successful project. Having intense client involvement in the construction phase can help Product Owners to steer clients towards right changes and decrease unnecessary changes since changes are inevitable in projects and particularly in construction projects. According to O'Brien (1975), many factors, like suggestions for changes in the design and environmental factors, trigger change orders and

change in scope in most construction projects, especially in the construction phase. Even though changes in construction projects is a phenomena, most of these changes are not welcomed and represent a risk to complete the project on time and within budget.

According to Lechler & Gao (2012), clients' expectations can change during the life cycle of the project and between phases which may lead to conflict and failures. This type of clients/stakeholders is what can be called Unaware or Resistant according to the PMBOK which can cause irrelevant changes and delays. Lechler & Gao (2012) suggests that involving clients in their project continuously keep them updated and keep the Project Manager and his team updated of their expectations and requirements that may change over different stages in the project. According to Lechler & Gao (2012), involving clients and having their input continuously during projects can increase clients' support toward their projects.

According to Choma (2008), change orders from clients and changes in design can cause serious negative risks on a project's scope, time and cost. (Assaf & Al-Hejji 2006) claims that most delays in construction projects occur because of "change order" which is usually requested by clients.

That being said, Clients, their requirements, and their expectations are focus points by their Consultants. Avoiding, eliminating or even dealing with risks that are Client related come first from a deep understanding of Clients' requirements and deep involvement of Clients' in their projects, especially in the construction process where a huge amount of work is done on site by the Contractor which makes any changes or rejections by Clients costly and time consuming. By applying Scrum, Clients stay involved in their projects by attending the sprint review meeting which makes understanding their requirements, expectations and their acceptance criteria clear to everyone in the team unlike the traditional methodology that lacks and which leads many project

to rework and changes. On the other hand, keeping Clients intensively involved in their projects, especially during the construction process increases Clients' understanding of their projects and performed works on site since it is not necessary that all Clients understand drawings and designs on paper but rather need to see tangible work on site which makes deeply involving this kind of Clients a necessity to avoid any conflict in the future due to misunderstanding or lack of requirements.

Involving Clients by applying Scrum to manage and control changes goes beyond the construction process where it has potential benefits in the initiation phase to understand Clients' requirements before commencing in design works and also make Clients understand all constraints and risks upfront before commencing in any additional or following work. Managing and controlling changes in the design phase can be one of the main strength points that Scrum can come up with in terms on dynamicity where having the Clients properly present in that phase can save a lot of time and cost by doing any necessary changes on the deign before translating that design to work on the ground where changes become extremely difficult and usually comes with negative impacts.

Another aspect that shows the dynamic nature of construction projects is evolving risks. According to Lukas & Clare (2011), one of the mistakes in managing a projects' risks is not being dynamic and not having this process as a continuous process. Having risks that may affect projects' baselines or any other type of risks that may affect people working on project need to be continuously and closely monitored and controlled regardless of the source of that risk. According to Hunsberger (2011), dynamic nature of Scrum and iterative sprints add more clarity to the project's scope and assist in avoiding scope creep.

Not only do iterative sprints in Scrum assist in keeping teams on track and avoid scope creep, but also Client involvement and daily Scrum meetings add to that dynamic nature.

Risks that are documented in a risk management plan along with a risk assessment plan do not stay in the same status and evolve as the project goes and why Scrum's intense monitoring and controlling aspect can be an added value to properly manage risks especially in the construction process by having risks always discussed among team members in daily Scrum meetings, retrospective meetings and with the Client in the sprint review meeting which by applying it all not only are identified risks under control, but new risks can be identified.

Project Manager's role during the construction process:

1. Create product log of all works to be inspected and checked by the team
2. Conduct daily Scrum meeting to discuss any concerns that may come up from the team before conducting inspection works
3. Following up during the day with the team for any quality concerns or violations by the contractor and collect the results of all inspections
4. Conduct sprint review meeting in the presence of the clients' to update them of the status of works, any delays, accomplished percentage, and obtain their formal approval on the performed works
5. Ensure proper documentation of accepted work by clients and proper documentation of lessons learned after each sprint
6. Monitor the progress of the contractor against the original time schedule and notify the contractor and the client of any delays or any risks of delays which by comparing dates of completed sprints (which is related to inspections of completed works) with the planned dates.

2.6.3 Conclusion

Even though a consultants' scope in the construction process is considered smaller than a contractors' scope, utilizing Scrum to manage certain aspects in this process can add value to the whole process for all parties, especially clients and end consumers. The dynamic iterative nature of Scrum makes it a strong methodology for monitoring and controlling which create strong platform to ensure high quality works that meet standards and clients' requirements and expectations. Along with the iterative nature that sprints create, a clients' intensive involvement is another strength point that Scrum outperform the traditional methodology and that is extremely important in such process, especially that not everyone is aware of with these type of works and a close interaction on site will have a great impact on the final short term and long term results even after the construction process. Leaving clients' involvement until the end of construction works or even lacking their participation can lead to serious consequences that affect schedule or create risks of delays, disputes amongst parties, or rework and creating changes.

2.7 Scrum within The Closing process group

This process is the last process of any project's life where the final project/product is turned to its Client after a successful process of handing over. The (PMI 2013) defines it as the formally used process group to close a whole project or a phase within the project through finalizing all related activities in all other process groups in that project or activities in a certain phase within that project.

Referring to the closing process group in figure (11) it can be observed that there are two processes that occur in this process group which are close project or phase, and close

procurements. Consultants in most projects are concerned with the process of closing the project/phase since contractors do all procurements. According to the (PMI 2013), at the closing project/phase process many activities can occur like documenting lessons learned, gaining formal acceptance from the Client to close the project phase, reviewing the end results after completing the phase/project, archiving all the important documents related to the project/phase, and releasing the project team members.

One of the most important tasks in the closing phase is documenting lessons learned according to the PMBOK 5th edition. The importance of lessons learned, according to Trevino & Anantatmula (2008), is that Project Managers can boost their future and current project by applying successful experiences and avoiding past failures. Also, (Chan & Kumaraswamy 2002), observed while studying factors that can contribute to delays in construction projects that utilizing lessons learned in new projects can highly prevent from practicing failures and mistakes again in these new projects. As mentioned earlier, the PMBOK mentions clearly that the process of lessons learned usually practiced in the closing process or late processes which may not be sufficient nor efficient in most of projects, especially complex and mega projects. According to Rowe & Sikes (2006), identifying lessons learned does not have to be at the end of a project and can be done during the project at any time which allows for that process to be properly done. Rowe & Sikes (2006) suggests that capturing and identifying lessons learned can be done various times during the project through sessions depending on the type and complexity of a project. Also, Rowe & Sikes (2006) claims that waiting until the end of the project to do the process of lessons learned may not be effective since team members will miss some key data and information that occurred and existed at earlier stages of that project. According to Grant (2009), most of the Project Managers conduct the process of capturing and documenting lessons learned at the end of the

project or end of certain phase, where Grant (2009) strongly suggests to do this process at earlier stages of the project and to be done often during the life cycle of the project.

Apart from collecting and documenting lessons learned, practicing the traditional methodology to close a project or a phase usually takes more time than what was originally planned and can lead to rework and conflict between all related parties in the project because of the below:

1. Collecting all necessary documents for the project closure can be a complicated task especially if many subcontractors are under the main contractor in the project which may lead to delays in order to coordinate between all subcontractors and to collect all handing over documents and manuals and after that its reviewed by the consultant
2. Obtaining a formal acceptance from the Client at the end of the project over all finished works can lead to delays and extra costs because of the possibility of not meeting the Client's requirements and expectations, quantity of ready works to be checked in the same time, and time required for testing and commissioning and familiarizing the Client with all systems in the project

All the above makes looking for a new methodology to apply valid and essential especially in the closing process where Clients' involvement is necessary and required in order to turn a product or a project to them and hand it over successfully in a formal process without any delays nor extra costs.

2.7.1 Mechanism of Scrum in the Closing Process

This section will highlight how Scrum framework can be utilized for the testing and commissioning process, reviewing all manuals and handover documents and turning the whole project to the client, plus it will show how Scrum can decrease the time and cost required for this process group.

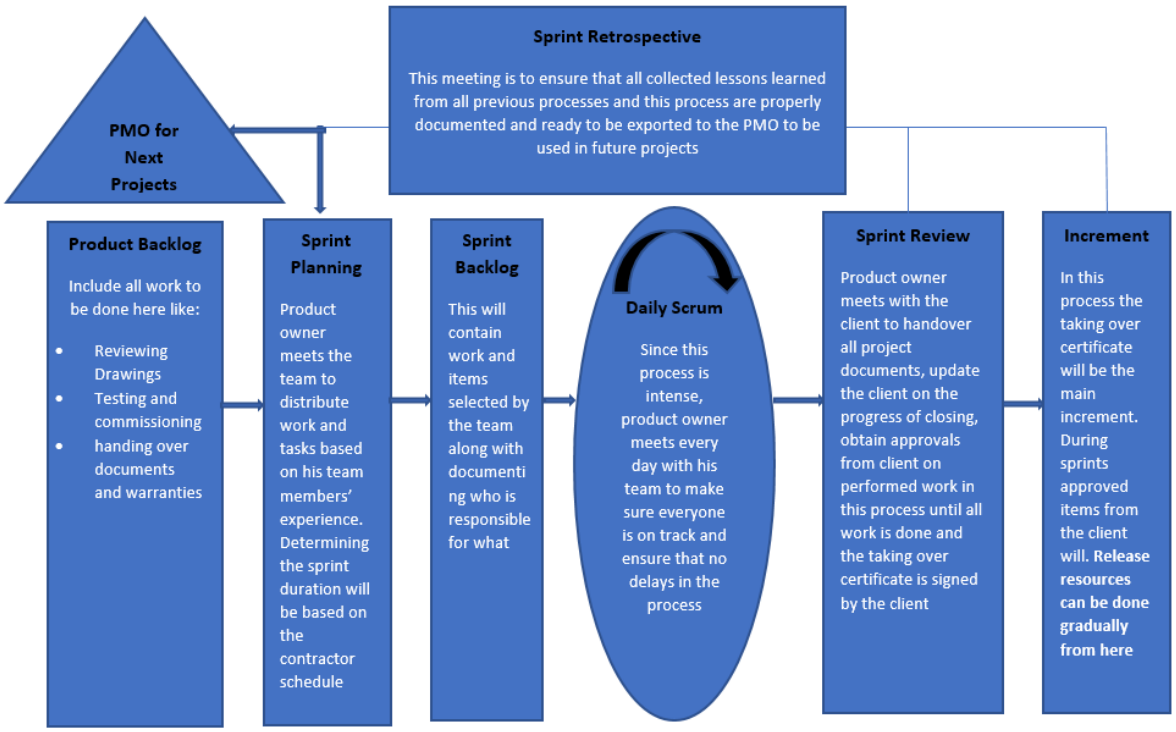

Figure (13). Scrum Framework in The Closing Process

Same as the previous processes, the start will be from the product backlog. Again, it is the Product Owner's responsibility in this phase to prepare the product backlog which can contain all systems that require testing and commissioning like firefighting and air conditioning systems plus key points to be tested in these items, manuals and maintenance guidance that need to be reviewed, and any other handing over document that needs to be reviewed and approved before

handing it over to the Client such as last updated drawings (as built), approved change orders (if any), warranties periodical test certificates, etc.

Testing and commissioning requires a clear schedule and clear procedure to be followed for each system before commencing in any works. Therefore, the product backlog needs to be properly prepared and detailed to fulfill this process group. The product backlog will contain work to be done for each task like testing and commissioning, reviewing manuals and as built drawings, conducting training for certain systems, etc.

As in the previous processes, sprints will flow one after the other until each task is fulfilled in the closing process group. It is worth mentioning that the PMBOK considers documenting lessons learned in this phase one of the major tasks, where in Scrum framework this process occurs in every process group after each sprint which makes documenting lessons learned part of each sprint and does exist in all processes groups and not only at the end of the project/phase which makes this process more effective, easier, and increases the performance of all team members as it adds to their experience. Also, obtaining a formal acceptance from the Client in order to start this process is easier when utilizing Scrum since there is always constant communication between the Client and the Consultant through sprints which makes gaining this approval easier and on time to avoid any delays or extra costs. Moreover, Utilizing Scrum by Consultants in the closing process group instead of the traditional methodology has many advantages on time and cost as below:

1. Documenting lessons learned will not be a largely time consuming task for team members since it happens after each sprint in all processes
2. Involving the Client in each sprint in the closing process helps him understand all systems used in the project and smooth’s the transition of the whole project to him/her

3. Having focused team members in achieving sufficient results in such process group assist in releasing resources to other projects to decrease costs and support other projects
4. Having clear detailed product backlogs create to a certain limit clear path for the Contractor and the Client to follow to avoid conflicts in such sensitive processes

Basically in this process group the Product Owner responsibilities are:

1. Prepare the product backlog related to the closing process including all tasks required to ensure proper handing over of the project
2. Determine the duration required to complete each task in the closing process, and decide on sprints duration based on the Contractor's schedule
3. Conduct daily meeting in the morning to make sure everyone is on the same page and the progress is on track
4. Coordinate with the Client to attend the sprint review meeting to check the accomplished work, and obtain acceptance on it before moving to following items
5. Release resources in a coordination with other projects and his upper management if those resources are not needed anymore on his project. This can be done gradually depending on the progress

2.7.2 Conclusion

From the above it can be observed that utilizing Scrum in the last process groups of any project life is quite effective and assists in proper closure of projects, especially with the Client's intensive involvement in this process and all the previous process groups which make the closing and handing over process group smooth and focused to successfully deliver a project that meets stakeholders expectations and requirements without the need to a modification or rework which leads to delays and cost overrun.

2.7.3 Burndown Chart

The burndown chart is a tool worth mentioning that can be utilized in all processes. As explained earlier and referring to figure (3), this tool is used to monitor and measure the performed work against the planned. Referring to figure (6), it can be observed that the monitoring and controlling process occurs within all process groups from initiation to the closing process group. Therefore, the burndown chart can be basically used in any process group to monitor the progress and stay on track. According to Al Behairi (2016), burndown charts can be useful in representing and tracking the progress in construction projects, while on the other hand Nee (2010), states that one of the strengths of the traditional project management methodology is that it offers wide variety of metrics tools that assist projects' teams in reporting and tracking while its limited for agile methodologies since it uses only burndown charts.

Although monitoring, controlling and reporting tools in Scrum are limited, consultants usually are not asked to create such charts and tables whereas all of it typically comes from contractors and consultants just review it. Burndown charts can be useful for consultants, especially in certain phases within the construction process to track certain tasks or scope that could represent risks to the projects' baselines as well as the intense monitoring from daily Scrum meetings and sprint review meetings assist in this aspect.

Chapter 3: Research Framework

The goal of this chapter is to come up with a conceptual framework that is structured based on the literature review and to fulfill the research questions. Two conceptual frameworks are established in this chapter that are inline with the research objectives to highlight main downfalls in the traditional project management methodology and where Scrum can be applied to add value to the whole process whether by resolving these downfalls or mitigate it. Both conceptual frameworks are the basis of the survey questions in order to have in depth comparisons between the survey findings and the literature review findings and analysis.

3.1 Strength Points of Scrum Framework and Their Effect

Scrum Framework strength points, as demonstrated in figure (14) along with their effect, come to resolve or mitigate the effect of the downfalls the traditional project management has in managing engineering projects by engineering consultants. Those strength points have been discussed in depth in the literature review that has shown in detail how Scrum adds value in these aspects and improves the whole process.

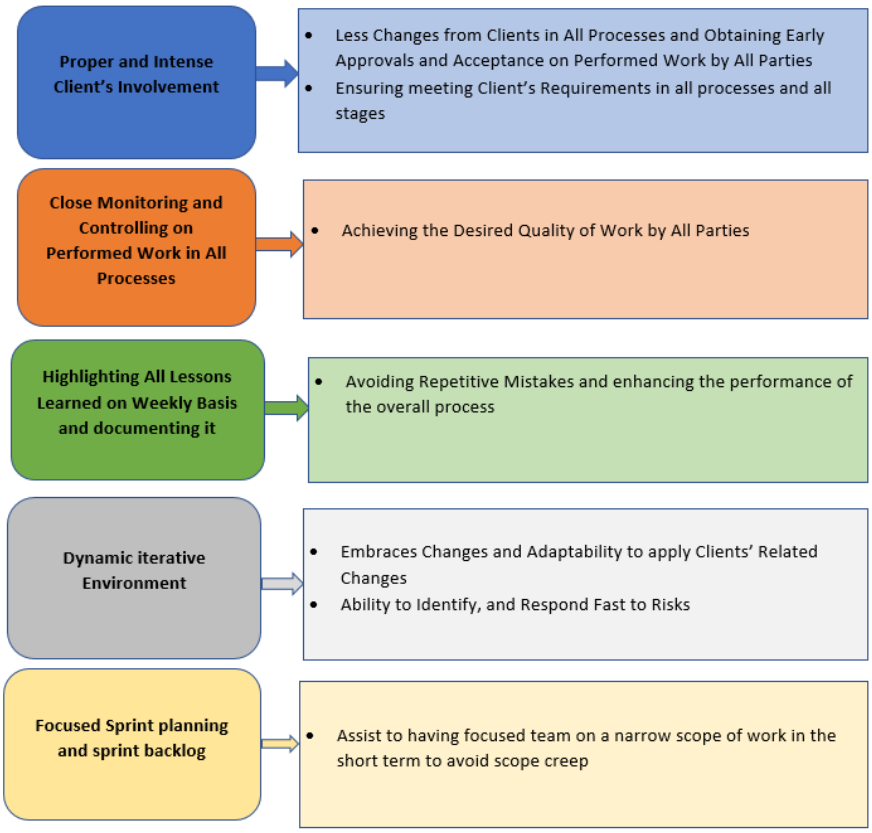

Figure (14). Conceptual framework of Scrum strengths and their effect

3.2 Research Hypothesis

The research hypothesis mainly will be developed based on utilizing Scrum in managing the five process groups within construction projects. Therefore, all aspects of Scrum (Intense client involvement, dynamic nature of Scrum, intense monitoring and controlling, process of documenting lessons learned) will be considered under the umbrella of Scrum and not individual independents. The research hypothesis are structured based on the conceptual framework and to answer the research questions and meet the research objectives.

H1: Intense clients' involvement contributes positively in controlling and decreasing client related changes

H2: Intense monitoring and controlling leads to better quality of performed works in the design and construction phases

H3: Dynamic iterative nature in construction projects create an alerted environment that identify and respond fast to risks and have the ability to adapt necessary changes at the right time

H4: Creating work-focused backlogs through sprint planning meetings assist teams to carry certain works without getting distracted and without scope creep

H5: Continuous collecting and documenting of lessons learned throughout construction projects from initiation until closing enhance the performance of construction projects overall

Chapter 4: Research Methodology

The purpose of this chapter is to illustrate the path taken in collecting and analyzing dependable and reliable data that assist the researcher in meeting this research's objectives and explain why this specific approach was taken. Also, this section highlights the selected research method, data collection method and the sampling tool used to collect data for this research.

4.1 Research philosophy

According to (Saunders, Lewis & Thornhill 2009), "The term research philosophy refers to a system of beliefs and assumptions about the development of knowledge." Research philosophy represents the way and how this research was developed and designed, plus the knowledge that based on it the researcher determined the procedure to collect data, analyze it and translate the findings. The researcher has to correlate between the research questions, objectives and type of data to be collected. According to Williams (2007), the research process needs to take a systematic approach where data and interpreted findings need to get connected and communicated with the established frameworks and objectives. In general, the most common research philosophies are positivist and interpretive. According to Shirazi (n.d) the positivist research philosophy is "a methodological philosophy in quantitative research where we will apply the methods of natural sciences to discover the study of social science." That being said, in the process of understanding a phenomena the relationship between dependent and independent variables needs to be clearly determined through a scientific and quantitative process. According to Mack (2010), the positivist research philosophy is an emphasis on having a scientific method, statistical analysis that is generalizable, and prove or disapprove hypothesis.

Pham (2018) states that the positivist philosophy is highly structured and that it focuses on bringing accurate and clear knowledge and aims to use only strictly scientific methods that leads to reliable and unbiased data. On the other hand (Sallee & Flood 2012) argues that the positivist research philosophy has many disadvantages and weaknesses like coming up with inaccurate and sometime biased scientific data and ineffective in generating in depth knowledge. However, the positivist research philosophy is still a widely used research philosophy and where it might be true that it does not provide in depth data and knowledge, it is still able to provide relevant and unbiased data that targets a research objectives and represents wide population by following the quantitative method of analysis.

In contrast, the interpretive research philosophy comes with a more subjective path. According to Pham (2018), the interpretive research philosophy focuses on creating a rich and complex understanding through in depth investigations based on qualitative methods that focuses only on small samples (small audience of participants) to bring unbiased and meaningful knowledge. The interpretive research can result in a rich outcome. It requires qualitative method of analysis, which means in depth and more complex data than what can be collected from a quantitative method of analysis in which usually requires interviews and having a smaller sample that may not be enough to represent the population. According to (Qualitative Research on Special Education Teacher Preparation 2014), outcomes of a qualitative research may not have much credibility to many decision makers. (Flick 2011) mentions that in conducting a qualitative research and having a small size sample, it may not represent the whole population and therefore cannot be generalized. Idowu (2016) argues that the analysis of a qualitative research data consumes a lot of time, and this affects directly the ability of generalizing this data in terms of time and urgency.

The construction industry in general is a massive industry, and construction projects in many countries directly impact a countries GDP and therefore, this research aims to collect data that represent a wide population of engineering consultants and other parties within construction that can have input in this research so the output of this research can be generalized with staying away from bias. While the researcher suggests and proposes a way to use the already established Scrum framework in managing different processes in construction projects and highlights some of the possible benefits from that, still wants to remain neutral and detached to obtain real valuable data. Also the time constraint of this research makes it necessary to collect and analyze data within a very limited time. Research goals and questions require statistical data that can cover many aspects of this research and assist in understanding the research framework and hypothesis along with identifying if there is any relation between dependent and independent variables. Accordingly, the positivist philosophy with quantitative research method of analysis in this research was followed to assure getting unbiased data that fulfills the research objectives and properly covers the targeted population.

4.2 Research Approach

According to (Wilson 2010), main research approaches are deductive or inductive. (Bernard 2011) states that the deductive approach is basically concerned with forming a research strategy to test hypothesis that were developed based on an existing theory. In contrast, (Adams, Raeside & Khan 2014), state that the inductive research is concerned with building up a pattern from observations to generate a theory. In short, deductive researches are building and based on existing theory and starts with certain hypothesis where inductive researches take bottom-up approach and are concerned in generating a new theory without having a ready hypothesis. Since

Scrum framework already exists and is developed and widely used within the software and IT industry, the researcher will only examine the effectiveness and efficiency and what are the possible impacts from utilizing it within the five process group in a construction project's life cycle from an engineering consultant point of view. Also, the framework will be used as it is without modifications of it but only twisting some roles within it and specifying in each process how the framework can best fit and function in a way that flows with the nature of construction projects on a consultant side. Therefore, this research uses the deductive approach to examine and validate the utilization of Scrum framework in construction projects.

4.3 Research Method

Depending on the research scope, objectives, and path, a proper research method needs to be followed and adopted in order to determine and identify the required data to be collected for the research.

The most common research methods are quantitative and qualitative. According to (Williams 2007), the quantitative research method builds on existing theories and involves a numerical approach. It uses the collected data to determine and identify unbiased reality that can explain relations between variables and accordingly can be generalized. On the other hand, (Williams 2007) states that the qualitative research methods generate and develop new theories. It enables one to come up with detailed results from being involved in the experience, as the results have a lot to do with the researchers point of view. Also, (Williams 2007) associates the quantitative method with the deductive approach and the qualitative method with the inductive approach.

The research method for this research is quantitative and it is considered the primary research method since the research is building up on an existing theory and the objectives and nature of

this research requires a questionnaire survey to collect the required reliable statistical data that can be generalized. In order to generalize, a large sample needs to be selected to take the questionnaire in order to represent the targeted population. On the other hand, the research uses qualitative research method as only a secondary research method represented by the literature review. The literature review is used critically to investigate and verify the ability of utilizing Scrum in construction projects within different process groups from an already existing data and knowledge. Also, it is used to draw the conceptual framework that is connected with the established hypothesis. Accordingly, this research is a deductive quantitative research. It is worth mentioning that there is a risk of having issues in the data, which makes up the literature review. According to (Teijlingen & Hundley 2001), literature review is a secondary source of data and is associated with some risks in terms of reliability, credibility of data resources and validity.

4.4 Sample

In order to have participants that have the required knowledge and experience in the research topic from many regions in the world, and to have a representative sample that properly reflects the population, the researcher followed the multi-stage cluster sampling. Firstly, the researcher divided the population based on geographical location in order to collect accurate data as much as possible since agile methodologies are still considered new, especially in the construction industry. After dividing the population geographically, the researcher divided it again to sub clusters based on project management experience mainly in the construction industry that is exposed to a kind of knowledge or experience in Scrum or Agile project management methodologies in general. Participants were from United Arab Emirates, United States of America, and Kingdom of Saudi Arabia.

4.5 Survey Instrument

Since the research requires a big sample that can accurately represent the population and bring to the table reliable and valid data that can be generalized, a proper survey instrument needs to be determined in order to be widely distributed to collect reliable and valid data. A survey questionnaire was properly and precisely developed to answer the research questions and meet the research aim and objectives. The questionnaire consists of three sections. The first section is concerned with participants' demographics, the second section is concerned with the background of the research which is major downfalls within the traditional project management methodology. The third section is targeting Scrum utilization within construction projects to test and examine how far Scrum can go in that path. Options for the second and third sections are mainly based on the Likert Scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree). The questionnaire was developed and designed to be effective, moderate in length and in a shape where it can be easily distributed to the participants. The questionnaire was developed using Google Survey service and distributed via e-mail. In the beginning brief of the questionnaire, the questionnaire includes, advices to participants on how to answer it, and stresses that all answers and collected data are anonymous and exclusively for this research only. A pilot study was conducted before releasing the questionnaire. (Lavrakas 2008), mentions many reasons behind conducting a pilot study on a questionnaire is that before releasing a questionnaire to the targeted sample it is important to identify any logistics issues in the questionnaire, verifying the protocol of the survey, verifying if the data analysis techniques are the best for this research and for a certain kind of data. The researcher conducted a pilot study on 18 random participants before distributing it to the targeted sample. The full questionnaire is presented under Appendix (A).

The questionnaire was distributed online to 60 participants. However, only 52 participants have responded to the questionnaire. Table (1) below shows the participants' demographics. The table shows that 94.2% of the sample has a kind knowledge/experience related to agile project management methodologies in general and 82.7% of the sample at least has a kind of knowledge about Scrum, where on the other hand 100% of the sample has between zero to two years of experience in Scrum. This could mean that the sample has no experience in applying Scrum or has a limited experience which does not exceed two years and that due to the fact that Scrum is a modern methodology that has started and grown in the IT and software industry, where from table (1) it can be seen that 90.4% of the participants are within the construction/engineering field which is generally big on the traditional management methodology and resist any changes.

Gender	**Frequency**	**Percentage**
Male	47	**90.4%**
Female	5	9.6%
Educational Level	**Frequency**	**Percentage**
High School	0	0%
Bachelor	11	21.2%
Master	41	**78.8%**
PHD	0	0%
Working Field	**Frequency**	**Percentage**
Construction/Engineering Design	47	**90.4%**
Risk Management	4	7.7%

Software and IT	1	1.9%
Others	0	0%
Seniority Level	**Frequency**	**Percentage**
Top Management	30	**57.7%**
Middle Management	22	42.3%
Junior Staff	0	0%
Intern	0	0%
Years of experience in Project Management	**Frequency**	**Percentage**
0-2	3	5.8%
2-5	3	5.8%
5-10	24	**46.2%**
10-15	22	42.3%
>15	0	0%
Years of experience in construction project management	**Frequency**	**Percentage**
0-2	6	11.5%
2-5	4	7.7%
5-10	20	38.5%
10-15	22	**42.3%**
>15	0	0%

Knowledge/Experience in Agile	**Frequency**	**Percentage**
Yes	49	**94.2%**
No	3	5.8%
Any knowledge about Scrum specifically	**Frequency**	**Percentage**
Yes	43	**82.7%**
No	9	17.3%
Years of Scrum experience	**Frequency**	**Percentage**
0-2	52	**100%**
2-5	0	0%
5-8	0	0%
8-10	0	0%
>10	0	0%

Table (1). Participants' Demographics (N=52)

4.6 Dependent and Independent Variables

Causality between different variables will be tested as per the hypothesis in section (3.2), which is created from having dependent and independent variables. According to (Huck 2007), the independent variable explains the dependent variable. (Huck 2007) adds that the independent variable is the cause for the result or the outcome that the dependent variable represents. In this

research the independent variable will be main characteristics and components that make up Scrum, and that always need to exist and be applied.

Independent variables are:

a. Dynamic iterative nature (Seen in continuous sprints and daily Scrum meetings)
b. Intense client involvement that happens in sprint review meetings
c. Proper collecting and documenting lessons learned that happens in retrospective meetings
d. Intense monitoring and controlling
e. Sprint planning and sprint backlog meeting

Dependent variables are:

a. Identifying, responding to risks and embracing changes
b. Quality of performed works in the execution and design processes
c. Clients' related changes (including meeting clients' expectations and requirements)
d. Performance in overall processes
e. Scope creep

The next chapter will demonstrate if there is a relation between the independent variables and the mentioned dependent variables, and if there is a relation; the extent of it.

Chapter 5: Data Analysis

This section of the research aims to analyze the data and present it in an easy way to target the research questions, hypothesis and the conceptual framework. Collected data is analyzed using descriptive statistical analysis and correlation analysis. The correlation analysis aims to test the hypothesis to identify if there is a relation between the independent variable and the dependent variables, which may give signs of causality. The researcher used the Statistical Package for Social Science to provide the correlation analysis and reliability test.

5.1 Reliability Test

This section aims to measure the reliability using Cronbach Alpha. (Moser & Kalton 1989) stresses on the importance of testing reliability, as it is concerned with the internal consistency of all parts within a research instrument. Reliability is not only concerned with the stability of certain measure but also with the repeatability, which according to Robinson (2010) means that a test is reliable if we can repeat its measure under the same conditions and get same results. To test the reliability within this research instrument the researcher uses Cronbach Alpha coefficient. Both (Whitely & Kite 2018) and (Nunally & Bernstein 1994) claim that when using Likert Scales, Cronbach alpha coefficient is commonly used and known for being the appropriate measure of reliability. According to Akoglu (2018), a Cronbach's alpha with value of 0.7 and greater is considered sufficient and reliable. Figure (15) shows the 0.946 as the reliability value, which is a high reliability which also contributes in zero deletion to any of the variables.

Case Processing Summary

		N	%
Cases	Valid	52	100.0
	Excluded[a]	0	.0
	Total	52	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.946	10

Figure (15). Cronbach's Alpha Value

5.2 Correlation Analysis

This section aims to highlight if there is a statistical relationship between two variables (independent and dependent) and the strength of that relationship. Bollen & Barb (1981) define the correlation as a "relation existing between phenomena or things or between mathematical or statistical variables which tend to vary, be associated, or occur together in a way not expected by chance alone." The researcher in this section will present the correlation between the five independent variables and other five dependent variables to test the developed hypothesis if they are rejected or not rejected. Based on the type of collected data, a proper correlation coefficient needs to be conducted using SPSS. The questionnaire utilizes Liker Scale, which is considered as an ordinal data. According to (Choi, Peters & Mueller 2010), when analyzing ordinal data, there are better alternatives than Pearson's coefficient like Spearman's or Kendall's, where (Kendall & Gibson 1990), argue that when dealing with Likert Scale data, or ordinal data in general, it is appropriate to conduct Pearson's to test the correlation, also (Guler & Uyanik 2013), states that

unlike Pearson's, Spearman's and Kendall's coefficients are limited when it comes to testing and measuring association between variables. Therefore, Pearson's coefficient will be conducted for all variables as per the developed conceptual framework and hypothesis. In the next section all conducted correlations will be presented along with testing the hypothesis that is related to it.

5.3 Hypothesis Testing

In this section, the conducted correlations will be used to test the developed hypothesis one by one and verify if there is a relation between the independent and dependent variables that make up those hypothesis.

H1: Intense clients' involvement contributes positively in controlling and decreasing client related changes

This hypothesis assumes that when clients are intensively involved in their project, better control over changes occurs and client related changes become less. Figure (16) shows a correlation of 0.800, which is a high degree of positive correlation. Also, figure (16) shows that this correlation is highly significant. Therefore, this hypothesis is accepted.

Correlations

		IntenseClientInvolvement	DecreaseChnages
IntenseClientInvolvement	Pearson Correlation	1	.800**
	Sig. (2-tailed)		.000
	N	52	52
DecreaseChnages	Pearson Correlation	.800**	1
	Sig. (2-tailed)	.000	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Figure (16). Correlation between Intense Client Involvement and Client Related Changes

H2: Applying intense monitoring and controlling results in better quality of performed works in the design and construction phases

This hypothesis assumes that when there is continuous and intense monitoring and controlling, a higher quality of work will become as a result with no need for reworks. Figure (17) shows a correlation of 0.583, which is a moderate degree positive correlation. Also, it shows high significance and therefore this hypothesis will be accepted.

Correlations

		Quality	MandC
Quality	Pearson Correlation	1	.583**
	Sig. (2-tailed)		.000
	N	52	52
MandC	Pearson Correlation	.583**	1
	Sig. (2-tailed)	.000	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Figure (17). Correlation between Intense Monitoring and Controlling and Quality of Performed works

H3: Dynamic iterative nature in construction projects create an alerted environment that identify and respond fast to risks and to adapt necessary changes at the right time

This hypothesis assumes that having dynamic and iterative nature in construction projects increase the effectiveness of responding to risks, including necessary changes, in an effective time manner. Figure (18) shows a correlation of 0.583, which is a positive moderate degree correlation and it is considered as significant since sig=0.00. Therefore, this hypothesis is accepted.

Correlations

		Risks	Dynamiciterative
Risks	Pearson Correlation	1	.583**
	Sig. (2-tailed)		.000
	N	52	52
Dynamiciterative	Pearson Correlation	.583**	1
	Sig. (2-tailed)	.000	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Figure (18). Correlation between The Dynamic Iterative Nature and Identifying and Responding To Risks

H4: Creating work-focused backlogs through sprint planning meetings assist teams to carry certain works without getting distracted and without scope creep

This hypothesis assumes that creating focused sprint backlogs assist teams to avoid scope creep and just focus on a certain scope of work for a short term. Figure (19) shows a Pearson's

correlation coefficient of 0.793, which is a positive high degree of correlation. Also, it is considered significant since Sig = 0.00. Therefore, this hypothesis is accepted.

Correlations

		Sprintbacklog	Scopecreep
Sprintbacklog	Pearson Correlation	1	.793**
	Sig. (2-tailed)		.000
	N	52	52
Scopecreep	Pearson Correlation	.793**	1
	Sig. (2-tailed)	.000	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Figure (19). Correlation between Utilizing Sprint Backlog within Scrum and Scope Creep

H5: Continuous collecting and documenting of lessons learned throughout construction projects from initiation until closing enhance the performance of construction projects overall

This hypothesis assumes that continuous collecting and documenting of lessons learned throughout a construction projects life cycle positively enhances the performance of team members by avoiding repetitive mistakes in the same phase, project or even other projects. Figure (20) shows significance and highlights positive moderate correlation of 0.525. Therefore, this hypothesis is accepted.

Correlations

		Lessonslearned	Enhanceperformance
Lessonslearned	Pearson Correlation	1	.525**
	Sig. (2-tailed)		.000
	N	52	52
Enhanceperformance	Pearson Correlation	.525**	1
	Sig. (2-tailed)	.000	
	N	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

Figure (20). Correlation between Proper collection and Documentation of lessons Learned and Overall Performance

It can be observed at the end of this section that although none of the hypothesis was null, they vary in the degree of correlation which means that not all the independent variables affect the concerned dependent variables in the same way and degree and this is why it is advisable to take another step to test the relation between these variables through conducting regression analysis

5.4 Regression Analysis

Regression analysis is a statistical analysis that aims to estimate the relationship between a dependent variable and an independent variable. According to (Guler & Uyanik 2013), these analysis are usually conducted after a correlation analysis and the main purpose of these analysis is to analyze and identify a linear relationship between a dependent and independent variable. Where correlation analysis gives an indication of the strength of a relationship between two variables, regression analysis gives an indication of the direction of this relation. Regression analysis's purpose is to predict the association nature and how the dependent variable acts and changes when applying changes on the predictor variable (Independent Variable). Here in this

section the linear regression analysis was conducted for all the dependent variables to further understand the nature of how they get affected by their independent variable to go more in depth in the developed hypothesis.

In the below tables, the researcher will go through different coefficients that will further explain the nature of each relation between independent and dependent variables and try to predict how each dependent will reach when changes occur to its independent variable. Linear regression analysis is used to go through each hypothesis and target certain dependents with the assumption that a certain independent has a significant effect on that dependent.

This is a simple linear regression analysis that includes one dependent and one independent variable and not multi-linear regression where more than that independent variable is tested. As illustrated below in the model summary table, the focus will be on Adjusted R square. Adjusted R square indicates the percentage of variance in the dependent variable that can be explained by the independent variable. From ANOVA table, the focus will be on the statistical significance of the model, which if it is significant, the independent variable is considered as a good predictor variable of the dependent variable. In general in order for the model to be significant it needs to be less than alpha (p), which is 0.05. if Sig >0.05 it will be considered as insignificant. Finally from the coefficient table, the focus will be on Standardized Coefficient Beta, which explains the variance of standard deviation in the dependent variable for increase of one standard deviation in the independent variable (Predictor). Also, the significance of a certain independent to create variance in a dependent can be seen from the coefficient table.

H1: Intense clients' involvement contributes positively in controlling and decreasing client related changes

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.800[a]	.640	.633	.275

a. Predictors: (Constant), IntenseClientInvolvement

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.737	1	6.737	89.054	.000[b]
	Residual	3.782	50	.076		
	Total	10.519	51			

a. Dependent Variable: DecreaseChnages

b. Predictors: (Constant), IntenseClientInvolvement

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.692	.134		5.166	.000
	IntenseClientInvolvement	.678	.072	.800	9.437	.000

a. Dependent Variable: DecreaseChnages

Figure (21). Regression Analysis Results of Intense Client Involvement and Decreasing Changes

Referring to figure (21), it can be observed that 63.3% of the variance that occur in decreasing client related changes can be explained by having intense client involvement which is considered as high explanation. Also, from ANOVA table it can be seen the model is significant ($p<0.05$). From the coefficients table it can be observed that each increase in the standard deviation of the intense client involvement causes a 0.800 increase in lowering client related changes. From these results it can be observed that this regression model is statistically significant and represents well a prediction of the dependent variable (Lowering Client Related Changes). Therefore, this hypothesis will not be rejected.

H2: Applying intense monitoring and controlling results in better quality of performed works in the design and construction phases

From figure (22) below, it can be observed that this model is statistically significant ($p<0.05$). Adjusted R square is 32.7%, which means only 32.7% of the variance in quality of performed work can be explained by intense monitoring and controlling. Beta coefficient from the coefficients table is 0.583, which means that for one increase in the standard deviation of intense monitoring and controlling there will be a 0.583 increase in the standard deviation of quality of works. Overall, this model is statistically significant. The predictor (intense monitoring and controlling) provides below average of explanation in the variance that occurs in quality of work. Therefore, this hypothesis is not rejected since the model is significant and provides some explanation about the variance in the dependent variable.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.583[a]	.340	.327	.353

a. Predictors: (Constant), MandC

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.210	1	3.210	25.759	.000[b]
	Residual	6.232	50	.125		
	Total	9.442	51			

a. Dependent Variable: Quality

b. Predictors: (Constant), MandC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.145	.143		8.015	.000
	MandC	.365	.072	.583	5.075	.000

a. Dependent Variable: Quality

Figure (22). Regression Analysis Results of Intense M&C and Quality

H3: Dynamic iterative nature in construction projects create an alerted environment that identify and respond fast to risks and adapt necessary changes at the right time

From figure (23) below, it can be observed that this regression model is statistically significant ($p<0.05$). Adjusted R Square is 32.7 %, which means that 32.7% of the variance in the identifying and responding to risks can be explained by the dynamic iterative nature of Scrum. Also, Beta Coefficient shows that for each one increase in the standard deviation of the dynamic nature there will be a 0.583 increase in identifying and responding to risks. Although the dynamic nature provides a below average explanation of the variance occurs in responding to risks, this model still statistically significant and therefore, the hypothesis is not rejected.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.583[a]	.340	.327	.353

a. Predictors: (Constant), Dynamiciterative

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.210	1	3.210	25.759	.000[b]
	Residual	6.232	50	.125		
	Total	9.442	51			

a. Dependent Variable: Risks

b. Predictors: (Constant), Dynamiciterative

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.145	.143		8.015	.000
	Dynamiciterative	.365	.072	.583	5.075	.000

a. Dependent Variable: Risks

Figure (23). Regression Analysis Results of Dynamic Nature and Responding to Risks

H4: Creating work-focused backlogs through sprint planning meetings assist teams to carry certain works without getting distracted and without scope creep

Figure (24), shows statistically significant model with p=0.00 (p<0.05). 62.1% of the variance in the avoidance of scope creep can be explained by utilizing the Sprint Backlog. Also, for each one increase in the standard deviation of the Sprint Backlog, a 0.793 increase occurs in the standard deviation of avoiding scope creep. The predictor (Sprint Backlog) provides high explanation of the variances occur in the avoiding scope creep, also this model overall is significant. Therefore, this hypothesis is not rejected.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.793[a]	.628	.621	.272

a. Predictors: (Constant), Sprintbacklog

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.235	1	6.235	84.521	.000[b]
	Residual	3.688	50	.074		
	Total	9.923	51			

a. Dependent Variable: Scopecreep

b. Predictors: (Constant), Sprintbacklog

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.130	.231		-.563	.576
	Sprintbacklog	1.026	.112	.793	9.194	.000

a. Dependent Variable: Scopecreep

Figure (24). Regression Analysis Results of Sprint backlog and Scope Creep

H5: Continuous collecting and documenting of lessons learned throughout construction projects from initiation until closing enhance the performance of construction projects overall

Figure (25), shows Adjust R Square value of 26.1%, which means that the predictor (Lessons Learned) provides below average explanation of variances that occur in the dependent variable (Overall Performance). Beta Coefficient is 0.525, which means for one increase in the documenting of lessons learned standard deviation, an increase of 0.525 occurs in the overall performance standard deviation. Even though the model does not strongly explain variances in the dependent variable, the model is still considered statistically significant with p=0.00. Therefore, this hypothesis is not rejected.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.525[a]	.276	.261	.511

a. Predictors: (Constant), Lessonslearned

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.979	1	4.979	19.036	.000[b]
	Residual	13.079	50	.262		
	Total	18.058	51			

a. Dependent Variable: Enhanceperformance

b. Predictors: (Constant), Lessonslearned

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.256	.324		.791	.433
	Lessonslearned	.731	.168	.525	4.363	.000

a. Dependent Variable: Enhanceperformance

Figure (25). Regression Analysis Results of Lessons Learned and Overall Performance

5.5 Conclusion

A reliability test was conducted and resulted with a high reliability value of 0.946 without excluding any item. After that the researcher targeted the five developed hypothesis to test the relationship strength between each dependent and independent variable. The researcher took certain individual independents that are parts or characteristics of Scrum framework to test how they can affect certain aspects within construction projects that were highlighted in the beginning of this research. Although not all five hypotheses have the same degree of correlation nor share the same regression analysis, they are all considered to be non-rejected and all correlation results came out as significant. H1 and H4 have the highest degree of correlation amongst their variables, and therefore the independent variables in both of them provide higher degree of prediction and explanation of the variance that occur in their dependent variables. Overall, since all hypothesis are not rejected and even if some of them do not have high degree of correlation they still give some explanation and direction of how things can develop when it is applied by professionals in different construction projects.

Chapter 6: Discussion and Findings Interpretation

This section demonstrates the main collected data collected by the research questionnaire and how that data is interpreted. Also, this section will compare this data with the data illustrated and discussed in the literature review in targeting the research aim and objectives. The collected data will be presented using descriptive analysis so it is easy to be interpreted and discussed.

6.1 Descriptive Analysis

This section will present the research data that is collected by showing frequencies and percentages to enable the reader to understand this data easily. After that, findings will be interpreted and discussed.

The researcher will refer to the traditional project management methodology in the tables below by using TPMM, Construction Project=CP,

6.1.1 Main Downfalls of The Traditional Project Management Methodology

The main downfalls in the traditional project management methodology that were highlighted in the background can be summarized into four main downfalls as listed below:

a. Low client involvement overall process groups from initiation until closing
b. Static and rigid nature in extremely dynamic environment
c. Insufficient Monitoring and Controlling in all process groups and especially the construction process
d. Insufficient and inefficient collecting and documenting of lesson learned

All of the above factors were discussed in the background to justify the need for a new project management methodology that can be utilized to enhance the overall performance of construction projects from initiation until closing. Table (2) below shows the collected data in regards to the same downfalls. Participants were basically asked if they agree or disagree with the presence of these downfalls within the traditional project management methodology. 96.2% of the participants (Between Agree and Strongly Agree) agreed that the traditional project management methodology has various downfalls when managing construction projects through different process groups. Regarding the first downfall, all participants agreed that this methodology lacks proper and intense client involvement which match what has been highlighted in the background of this research that even though the traditional project management methodology represented by the PMBOK focuses and demonstrates stakeholders' roles and engagement in their projects, yet there still exists a lack in this aspect. The 96.2% of the participants (Between Agree and Strongly Agree) clearly contradict with the PMBOK path when it comes to stakeholders and client management which as discussed in section (1.1), the PMBOK as it represents the traditional project management methodology has a clear path in managing stakeholders and sponsors but yet as (Kerzner 2003) claims, this path does not make customer needs a priority, where Bowie (2003) adds that a more customer driven approach needs to exist in the traditional methodology and needs to be specified as a knowledge area within the PMBOK. The fact that all participants agreed on this downfall means that this point was valid in many projects where those participants had to experience it which makes it an important point that needs attention and an effective response.

Moving to the second point, 90.4% of participants believe that the traditional project management methodology suffers from being rigid and static where the environment of construction projects in general, and especially in the design and construction processes, is dynamic and active. This contradicts with what (Collyer *et al* 2010) states in his paper that many professionals within the construction industry believe in the traditional project methodology in responding to changes and they do not embrace changes in general. On the other hand, most participants agree with Ganis (n.d) and Nassar (2009) that there is a dynamic and competitive nature within construction projects and that the traditional project management methodology is rigid and inflexible. Lechler & Gao (2012) adds that the dynamic nature of construction projects is formed from evolving risks from many factors such as environmental factors or continuous changes in clients' requirements and expectations.

As changes and risks, in general, are not likable in construction projects, especially in the construction and design processes, it is still inevitable and require proper response while at the same time many Project Managers still believe in the sequential pattern as the best possible practice when it comes to managing construction projects and they stick to the static nature instead of having continuous dynamic strategy to deal with the evolving nature of construction projects.

Many professionals within construction projects nowadays are familiar with the rigidity of the traditional methodology and how ineffective is that when it comes to managing changes and responding to risks through different phases in construction projects' lifecycle. Participants in the questionnaire have a strong opinion as to the static sequential nature in the traditional methodology and that it is a negative aspect and cannot keep up with the dynamic nature and evolving uncertainties regardless of the source of these risks and uncertainties.

Moving to the next point, 94.3 % of the participants agree that the traditional project management methodology suffers from insufficient monitoring and controlling which matches what was discussed by Tengan & Aigbavboa (2018), and Puspasari (2005), and the participants probably referred to the design and construction processes that require intense monitoring and controlling to avoid quality issues, staying on schedule, and having solid knowledge of all works performed in these two processes. On the other hand, this large percentage of participants contradict with what the PMBOK comes up with since in many instances it portrays that all other processes float in a Monitoring and Controlling atmosphere, but when it comes to following the PMBOK through its five process groups and knowledge areas, the focus is on the process itself or creating a certain management plan but lacks Monitoring and Controlling and all other variables and lacks in having a clear holistic view that cannot be valid until more efforts are paid by the whole team on a daily basis or even shorter terms as needed.

Regarding the last mentioned downfall in this research, 98.1% of the participants agree that the traditional project management methodology lacks proper and efficient collecting and documenting of lessons learned. As discussed in section (2.7) in the PMBOK this process is usually left to the closing process, where Rowe & Sikes (2006), and Grant (200) stress that collecting documented lessons learned needs to happen more often and not only at the end of projects which may lead to missing valuable information and experiences. The participants in this aspect agree with Trevino & Anantatmula (2008), and (Chan & Kumaraswamy 2002) that effective and more often documentation of lessons learned keeps teams away from repeating mistakes and boosts the overall performance of current projects and future ones.

The above statistical percentages shows that the need for a better practice that replaces or at least supports the traditional project management methodology is needed, especially that these results were collected from professionals that vary in the type and duration of experience within managing construction projects.

Efficiency of TPMM	Strongly Agree	Agree	Natural	Disagree	Strongly Disagree
TPMM has many downfalls when managing CP from initiation until closing	50%	46.2%	3.8%	0%	0%
TPMM lacks proper client involvement in CP	67.3%	32.7%	0%	0%	0%
TPMM lacks sufficient	23.1%	71.2%	3.8%	1.9%	0%

monitoring and controlling in all CP phases, especially the construction phase					
TPMM static and rigid in nature	23.1%	67.3%	9.6%	0%	0%
TPMM lacks efficient documenting of lessons learned	17.3%	80.8%	1.9%	0%	0%

Table (2). Downfalls of The Traditional Project Management Methodology

6.1.2 Scrum in Managing Construction Projects from Initiation until Closing

This section will highlight the current status of actual Scrum usage within the construction industry as per the collected data from professionals in three different countries. Also, this section will demonstrate how Scrum can be beneficial in certain aspects when utilizing it to manage different process groups in construction projects. The end of this section will present the

answer to the first research question which is “Where can Scrum be utilized in managing construction projects from a consultant’s point of view?” to show the most benefited process groups from Scrum and the effect of that on it.

Status of Scrum usage in managing construction projects from Initiation until Closing	Very Common	Common	Rarely Used	Does Not Exist
	3.8%	3.8%	78.8%	13.5%

Table (3). Current Status of Scrum in Managing Construction Projects

Referring to table (3) above, 78.8% of the participants agree that Scrum usage in managing construction projects from initiating until closing is rarely used, while only 3.8% agree that its usage is very common, 3.8% agree that it’s usage is common and 13.5% believe that Scrum usage in managing construction projects does not exist at all. These percentages show that it currently is very rare to see Scrum in construction projects which goes hand in hand with figure (5) in section (2.2). Also, these percentages confirm what was mentioned in section (2.5) where Jin (2018) claims that the usage of Scrum in the design process by Project Managers is still quite limited due to their limited knowledge. As any other new methodologies or technologies, the construction industry faces resistance to Scrum utilization which can be overcome by training and practicing it in small phases within any of the five process groups.

6.1.3 Scrum in the Initiation Process

This section sheds light on Scrum's effectiveness within the initiation process as discussed in section (2.4) in the literature review. As mentioned before in section (2.4), the PMBOK stresses that it's the project sponsors' responsibility to develop the project charter which contradicts with Brown (2005) as he argues that the Project Manager has to be deeply involved in this process as it enhances the understanding of the project's objectives and requirements by both the client and the Project Manager. Referring to table (4), 92.3% of the participants agree with utilizing Scrum in the initiation process to come up with the project charter and the stakeholders register. Also, (Owen *et al.* 2006) argues utilizing agile methodologies in this process and having the client deeply involved is highly beneficial. The above shows that having both Clients and Product Owners deeply involved in the initiation process boosts the process itself and will have a positive effect on the project and all stakeholders in general by understanding project objectives and clients' vision at an early stage and create a healthy environment of communication between different parties.

6.1.4 Scrum in the Design Process

As discussed before in section (2.5.1), Consultant Project Managers and Clients usually are not being deeply involved in this process which according to Jin (2017) a huge part of any project's success comes from a successful integrative design that in a lot of times, as (Yang & Wei 2010) claim, cannot be achieved because of Client changes. Referring to table (4), 92.3% of participants agreed that applying Scrum in the design process results in a comprehensive design that is approved by the Client and can be utilized in the construction process with minimum changes. Even though Jin (2017) claims that applying Scrum in this process cannot be effective

or efficient because of the Project Managers' limited experience in the agile methodologies, the concept of having structured intense Client involvement in a dynamic iterative nature is effective and indeed considered an added value. 73.1% of participants agree that flexibility along with intense Client involvement assist in embracing necessary changes in different processes which approves with what (Theis *et al.* 2016) suggests that even though the traditional project management methodology is effective in representing critical paths and tracking schedules, yet still practicing more collaborative and dynamic approach in such processes proved to be more effective, especially when responding to risks and high uncertainties.

Wideman (1981) states that the majority of Clients lack awareness of required time to imply changes and modify on the design, which can be resolved as Liu (2018) recommends by early Client involvement which goes hand in hand with what participants believe since 98.1% of them agree that having the Client deeply involved in the design process assists to a high degree in achieving comprehensive design.

These dual features of Scrum (intense Client involvement and dynamic iterative nature) can extremely boost the performance in the design process and have a better grip on Client related changes. These features are proven to have a positive and significant relation with decreasing changes and responding to risks (which can be considered Clients' changes) in section (5.2) and (5.4).

Another aspect that was discussed in section (2.5.1) is developing a product backlog that serves as a requirements traceability matrix which contains all Client and key stakeholders requirements before commencing in design works to avoid rework and ensure Client satisfaction. 88.4% of participants agree that the product backlog can be used as a requirements document and a WBS

(Work Breakdown Structure) sheet that shows all work to be completed, where 92.3% of the participants agreed that a product backlog can serve as a requirements traceability matrix to organize Client requirements before proceeding in design works. Product backlogs acting as WBS may not sound applicable to many professionals knowing that these work structures usually require complex software, but as a Consultant Product Owner the quantity and type of work is totally different than a Contractor's scope of work which may make it useful during this process to breakdown the design scope.

6.1.5 Scrum in the Construction and the Monitoring and Controlling Processes

As discussed in section (2.6), a Consultants' scope revolves around ensuring quality and compliance with Client requirements. As known, to ensure quality on a daily basis on construction sites a proper and intense monitoring and controlling needs to be applied. Scrum, with its features and components, creates a strong and effective environment of monitoring and controlling by applying daily Scrum meetings, sprint review, and retrospective meetings to prevent and mitigate any possible mistakes that may occur in the future. Referring to table (4) below, 96.2% of the participants agree that daily Scrum, sprint review, and retrospective meetings boost the monitoring and controlling process. Moreover, 86.5% of the participants agree that by applying Scrum in the construction process it will enhance the monitoring and controlling which leads to better quality of performed works and meeting Client requirements and expectations, and decrease Client related changes in this process as well. Puspasari (2005) claims that even with having clear guidelines for monitoring and controlling, still many construction projects are not able to meet their objectives and meet the required quality criteria.

(Tengan & Aigbavboa 2018) state that a projects' performance can be negatively affected by inconsistency of monitoring and controlling through different processes and can be poorly practiced by Project Managers. Accordingly, clear monitoring and controlling guidelines could exist in the PMBOK, but still the intensity and consistency of monitoring and controlling that exists within Scrum and get practiced in a structured way can be beneficial in general and especially within the construction process to ensure that everything is getting built according to approved drawings, specifications and meeting Client requirements at an early stage without the need to demolish any works and have delays and rework.

As shown in sections (5.2) and (5.4), the tested hypothesis H2 (applying intense monitoring and controlling results in better quality of performed works in the design and construction phases), shows positive significant correlation between intense monitoring and controlling and quality of works.

A monitoring and controlling tool that was mentioned in the literature review in section (2.7.3) is the burndown chart. Although this chart can be a great tool to track the progress of Contractors or even the progress of inspections or completed items by Consultants, only 48.1% of the participants agreed that it can be a useful tool to track a projects' progress. This low percentage from professionals represents the weakness of this tool comparing to what is usually used in construction projects to track progress like KPI's, LOG's, reports from scheduling software's such as Primavera…etc. which give more in depth information, higher accuracy, and can be more effective than a simple burndown chart that may not be compatible with the needs or quantity of data that need to be reported and monitored.

Apart from monitoring and controlling, 86.5% of participants voted that applying Scrum in the construction process can assist in decreasing Client related changes by having the Client deeply

involved. This matches what Kerzner (2003), Bowie (2003), and Fair (2012) mentioned and stress on. It is safe to say that changes in general are not welcomed within construction projects and especially in the construction process since it always lead to delays, rework, cost overrun and sometimes conflict and dispute. Therefore, almost all Project Managers whether they are Contractors or Consultants thrive to avoid changes. The same is when Project Managers act as Product Owners, they still want to avoid changes and make sure that performed works by Contractors within this process is approved and meet Client expectations.

6.1.6 Scrum in the Closing Process

Where this process may seem the least important among all other process groups for Consultants because of the tasks performed in it, it still could lead to major disputes, delays and cost overruns if it is not performed well. As discussed in section (2.7), a Consultant's scope in this process revolves around reviewing, approving and preparing the project handover documents to the Client in coordination with the Contractor. This may include testing of the project's systems, minor rectifications in construction works (snagging works) and more. One important task that the PMBOK highlights in this process is documenting lessons learned. As previously mentioned, by applying Scrum the process of collecting and documenting lessons learned becomes an iterative continuous process within all process groups and not only the closing process group which allows for effective documentation and free time in the closing process to focus on meeting Client requirements and expectations and have a successful handing over. Referring to table (4) 96.2 % of participants agree that the retrospective meeting allows for proper collecting and documenting of lessons learned. This contradicts with the PMBOK as it focuses on this process only at end of projects or end of phase where Rowe & Sikes (2006) and Grant (2009)

recommend that this process should be done various times during a project's lifecycle without waiting until the end of a project as many Project Managers do. Doing this process more often during a project lifecycle will make this process more effective and will allow for more time in the closing process.

Moreover, 94.3% of participants agree that Scrum in the closing process creates a focused environment, only on what needs to be done in this process, which assists in avoiding distractions and rework. Also, they agreed that by utilizing a focused sprint backlog by certain team members, assists in releasing resources to other projects instead of not having specified responsibilities and scope of work in this process. The closing process may not highly benefit from applying Scrum directly, but it collects all efforts done through other process groups like intense Client involvement that means approving all works done in the construction process prior to closing, proper monitoring and controlling, and sufficient documenting of lessons learned instead of doing it completely in the closing process.

Utilization of Scrum in managing CP from initiation to closing	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Project Manager can fit as Product Owner	38.5%	57.7%	0%	1.9%	1.9%
Project Manager can fit as Scrum Master	3.8%	13.5%	5.8%	50%	26.9%
Product backlog can act as a requirements register and WBS for consultants	11.5%	76.9%	11.5%	0%	0%
Sprint backlog keeps the team focused and	9.6%	86.5%	1.9%	1.9%	0%

assist in avoiding scope creep					
Daily scrum assist Product Owners in responding to risks and keeping the team on track	19.2%	78.8	1.9%	0%	0%
Sprint review meeting boosts clients' involvement and assist in meeting their requirements and expectations	40.4%	57.7%	0%	1.9%	0%
Retrospective exponentially improve the performance of projects by having	15.4%	80.8%	3.8%	0%	0%

proper lessons learned collecting and documenting					
Flexibility along intense client involvement assist in applying changes in different phases within projects	7.7%	65.4%	3.8%	5.8%	17.3%
Having daily scrum, sprint review, and retrospective meetings iteratively boosts monitoring and controlling	23.1%	73.1%	0%	1.9%	1.9%

overall all processes					

Utilization of Scrum in managing CP from initiation to closing	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Burndown chart is a great tool for consultants to report and track a project's progress	9.6%	38.5%	9.6%	42.3%	0%
Intense client's involvement decrease client related changes and ensures meeting client's	25%	73.1%	0%	1.9%	0%

requirements and expectations					
Applying Scrum in the initiation process results in better understanding of project's requirements, objectives and by the client and the Product Owner	32.7%	59.6%	7.7%	0%	0%
Applying Scrum in the design process results in product backlog act as requirements traceability matrix that	38.5%	53.8%	5.8%	1.9%	0%

contain all clients' requirements					
Applying Scrum in the design process will result in a comprehensive design without the need to changes on it in the construction process because of client's deep involvement in the design	38.5%	53.8%	5.8%	1.9%	0%
Scrum in the construction process boosts monitoring and controlling, ensures	25%	61.5%	13.5%	0%	0%

meeting clients' requirements and decrease client related changes					
Scrum in the closing process create focused environment to tackle all work in this process by having clear product backlog, daily Scrum, sprint review meetings	23.1%	71.2%	3.8%	1.9%	0%
Scrum in closing by having clients in the process assist in clients'	28.8%	67.3%	3.8%	0%	0%

understanding their project and smoothen the process to release resources without delays					
Having focused sprint backlogs that is assigned for certain teams in the closing process assist in recognizing completed certain scope of work to release resources to other projects	28.8%	63.5%	3.8%	3.8%	0%

Table (4). Utilization of Scrum in Managing Construction Projects from Initiation until Closing

6.2 Most Benefited Process Groups from Scrum

After going through the data collected regarding utilizing Scrum in the five process group, this section sheds light on the most benefited process groups from applying Scrum within it. As previously discussed, Scrum can be applied in all process groups and can be an added value to all process groups with its features and components, but to determine which process group acts as the best environment and can gain the most from Scrum, participants were asked to vote for that. Referring to table (5) below, 46% of participants voted for the monitoring and controlling process to be the most benefited process group from utilizing Scrum. This result can be simply explained by knowing and understanding the mechanism of Scrum and how the iterative and dynamic nature of it boosts the monitoring and controlling aspect. Also, the monitoring and controlling process is a process that exists internally in all other process groups from initiation until closing where engineering consultants can practice their role, especially in the design and construction processes.

32.7% of participants voted for the design process group as the most benefited process from Scrum after Monitoring and Controlling. This can be referred to the client intense involvement in this process along with the Product Owner, which assists to a high degree in creating comprehensive design that meets clients' requirements and expectations with the minimum changes in the design process and construction process. The design process is an essential process for a consultant since it is the process where they create the project on paper before assigning a contractor to build it. Having the minimum or no changes from clients particularly in the construction process is not only beneficial to the consultant and the contractor, but it is also important for clients to avoid any legal obligations to the contractor or dispute with the contractor if any delays occur because of due changes. It is worth to mention that most of the

available literature that was reviewed came from previous experiences and studies of applying Scrum within the design process group which makes it a popular process for Scrum application, especially for engineering consultants.

9.6% of participants voted for the initiation process where only 7.7% voted for the construction process and that could be explained by the Consultants role in each process. Consultants' role in the construction process revolves around supervising quality of works that get performed by the contractor and monitoring the whole progress on construction sites. This takes us back to the monitoring and controlling aspect, which is ranked as the most benefited process from Scrum. The initiation process between consultants and clients is an important process since its outcome determines high level requirements, high level risks, budget, main constraints, duration, and other important information that needs to be gathered before obtaining an official approval from the client to start the project. Having intense Product Owner involvement that represents the consultants, along with proper client involvement, assist in creating strong understanding of project's requirements and risks along with getting to know the nature of key stakeholders at an early stage and for all these reasons participants ranked the initiation before the construction process.

The Closing process group was ranked the least benefited from Scrum which can be explained by highlighting that this process is seen as a results collector process that does not have the same amount of sprints that could occur in the design or construction processes as it is focused in nature and usually seen as least important. While from another angle this focused nature came from applying Scrum in all process groups before the closing process group, which results in ready work for the handing over that is already approved by the client.

At the end of this section, the answer to the research question (Where can Scrum be utilized in managing construction projects from a consultant's point of view?) can be that Scrum can absolutely be used in all process groups and can add value in each one, but from a consultant's point of view and according to his responsibilities and role, Scrum can clearly shine in the Monitoring and Controlling and Design process groups where clients' requirements and expectations are collected and performed by both the contractor and the consultant and where money and time are spent the most.

Processes	Initiation	Design	Construction	Monitoring and Controlling	Closing
Which Process can benefit the most by utilizing Scrum	9.6%	32.7%	7.7%	46.2%	3.8%

Table (5). Most Benefited Process Groups from Scrum

6.3 Project Manager Role in Scrum

This section is concerned with which Scrum role best fits Consultant Project Managers. This section provides the answer of the second research question "How Project Managers (Consultants) can practice Scrum in managing projects through different phases?"

According to the collected data, 96.2% of participants agree that Project Managers should adopt the Product Owner role while practicing Scrum knowing the Product Owner main responsibilities are as below:

1. Deep understanding of the project/product
2. Knowledge of all work that needs to be done within the project and document it in a product backlog
3. Proper and deep involvement in the project
4. Close interaction with the technical team
5. Responsible for the success of the project

On the other hand, only 17.3% agree that Project Managers fit as Scrum Masters. From looking at the Product Owner role and the Scrum Master role as discussed in section (2.1.3), it is clear the Product Owner's role is more compatible with the Project Manager role, although as mentioned by (Sverrisdottir, Ingason & Jonasson 2014) the Product Owner role can be confusing to Project Managers as it seems to be more like a Client role, because of the financing part, but when practicing that in construction projects Clients are clear and they finance projects where Product Owner's get deeply involved in the whole process with all team members and the most important closely with Clients to achieve the best results.

6.4 Scrum Effect on Project's Cost, Time, Risks, and Client Involvement

This sections aims to answer the last research question which is "What is the impact of utilizing Scrum in different phases of construction projects regarding time, costs, and client involvement in their projects?"

From the tested five hypothesis it can be observed that five components and features of Scrum were taken as independent variables to check their impact and effect on other five dependent variables.

Quality, Client related changes, Risks, Scope Creep, and the overall performance showed relation with Scrum features and components as shown and discussed before. When having controlled client changes and a dynamic iterative nature that can identify and respond fast to risks, there is a higher possibility

To have a complete project on time and within budget. Also, by having the focused nature of Scrum that comes from sprint backlogs, daily scrum, and sprint review meetings assist in keeping everyone in the team on track and do only the required work without scope creep. The high and intense monitoring and controlling that comes from daily scrum meetings and iterative sprint review increases quality of performed works and assure meeting clients requirements and expectations. All the previous along with the result presented in table (4), shows that Scrum encourages client involvement throughout all process groups and lowers risks that are related to client changes. Although the burndown chart is not a strong progress tracking tool, still the monitoring and controlling aspect in Scrum strong and valid. By having dynamic nature and client intense involvement there is a higher probability in meeting projects' objectives on time and within budget along with enhancing the overall performance in the same project and other project by through continuous developing of lessons learned logs.

Chapter 7: Conclusion

Construction projects around the world are considered one of the most important factors that determine how developed a country is. Therefore, having successful construction projects from A to Z is extremely important, especially that construction projects consume a lot of money, time and effort. Utilizing the traditional project management methodology that is sequential in nature and represented by the PMBOK has proven to have some downfalls when managing construction projects from initiation until closing. Those downfalls that were highlighted in this research are low client involvement, lack in monitoring and controlling, static and rigid nature, and lack of documenting lessons learned. Scrum as an agile project management methodology, excelled in the software industry as being known as a dynamic iterative methodology that has a structured and strong Client involvement along the project. This research examines the utilization of Scrum to manage construction projects from initiation until closing from a Consultant point of view. Through this research, Scrum was applied within the five process groups to examine if it can be applied and useful to overcome some of the traditional project management methodology downfalls or not. It was shown in the literature review and from the questionnaire data that Scrum can be applicable in all process groups and can add certain values in each process group where on the other hand still can be more valuable and add potential values to certain process groups than other. Scrum excels in the monitoring and controlling process since this process can be considered a permanent feature and strength point within Scrum which is generated from its iterative nature, daily Scrum meetings and the Sprint review meeting. The other process groups that Scrum has been found to be valuable in is the Design process group and that comes from Consultant's scope in construction projects and how Scrum can add value to this process. Intense Client involvement in the design process can fasten the process overall, decrease changes after

completion of design, decrease changes in the construction process and create a design that meets Client requirements and expectations. According to the collected data, Scrum was found to be more beneficial in the Initiation process more than the Construction process and that can be referred to the Consultant's scope since in the initiation process Consultants spend a lot of time with Clients to understand their requirements and expectations and their role in the construction process relatively not as intense as a Contractors' scope. The closing process group found to be the least benefited from Scrum. In this, participants probably did not find Scrum can add direct value, where this process can collect various benefits from applying Scrum in the other process groups.

The second research objective was to highlight how Project Managers can fit in Scrum and what is the best role from Scrum for them to adopt. It was determined from the literature review and the collected questionnaire data based on the Project Managers responsibilities, skills, and knowledge that Project Managers best fit as Product Owners within Scrum as it is the most compatible role that is deeply involved in the projects and in close contact with Clients.

The third and last research objective is to highlight the advantages of applying Scrum and what are its strengths and what is the impact on projects from it. Many features and advantages were highlighted in the literature review and through the analysis of the collected data. Scrum excels in bringing Clients to the table and keeps them effectively in loop through a structured way so they continuously have their input, keep an eye on the performed work by Consultants and Contractor's to ensure compliance with their requirements and meeting their expectations. Also, Clients' structured involvement assist in avoiding changes or at least commence with at the right time to avoid rework. Another strength point within Scrum is the iterative dynamic nature that is

generated from the iterative sprints that make up Scrum. This dynamic nature assists in responding to risks, especially Client related changes in the design and construction processes. By conducting sprint retrospective meetings during every sprint, all lessons learned whether they are certain experiences, mistakes, or certain requirements will be documented and stored properly for the same project or future projects which will allow to enhance the overall performance by not wasting time in same mistakes or ineffective experiences.

The last feature that was identified and highlighted in this research is the intense monitoring and controlling that Scrum creates by having the daily scrum meeting, sprint review meeting and repetitive sprints that allow for close and intense monitoring, tracking and reporting.

Scrum can also assist in avoiding scope creep by having the dynamic nature with high monitoring and controlling and the Client deeply involved.

The impact of Scrum on construction projects through different processes will be for the most part a positive impact where Client deep involvement, the iterative dynamic nature, having solid record of lessons learned, and boosting the monitoring and controlling will enhance the overall process and will result in completing projects on time and within budget which was explained in this research.

Even though Scrum has many strengths and great features, it lacks in having strong monitoring and tracking tools like what is usually used in construction projects. Where in construction projects there are a lot of KPI's, LOG's and many softwares that assist in tracking and monitoring, Scrum has only the burndown chart which is not considered as effective and efficient like other tools. This can be easily replaced by having the usual tools while applying Scrum.

In the end, Scrum can be considered as an alternative to the traditional project management methodology, even though it still not widely used and not accepted but this can be overcome by proper training and highlighting its strength that can be a great value to Consultants in construction projects.

7.1 Limitation of This Research Work

As the research met its objectives and answered all research questions, many limitations of this research exist. One of the biggest limitations is not being able to find sufficient and reliable resources of data that can be in the literature review that is related to Scrum utilization in the construction, closing and initiation processes which is due to it being a new methodology that is widely used in the software domain not in the construction industry. Another limitation was reaching out to professionals that have sufficient amounts of knowledge and experience in construction and the agile methodologies which pushed the researcher to look out in various countries to collect the required data which limited the researcher's ability to reach a larger sample in one location and to have data coming from more experienced people in Scrum.

7.2 Recommendations for Future Researches

This research focused on Scrum utilization to manage construction projects from initiation until closing from a consultant point of view. It could be beneficial if a research goes through the application of Scrum from a contractor point of view in design and build projects or applying Scrum to monitor and control critical phases within the construction process only as many crucial scopes within the construction process can lead to delays and cost overruns, while having the client involved to maximize his/her satisfaction.

References

Adams, J., Raeside, R. & Khan, H. T. A. (2014). *Research Methods for Business Social Science Students.* London: Sage Publications.

Akoglu, H. (2018). User's guide to correlation coefficients, Turkish Journal of Emergency Medicine, Vol. 18(3), pp. 91-93.

Al Behairi, T.A. (2016). AGISTRUCT: improved model for agile construction project management. *PMI® Global Congress 2016.* Project Management Institute. Barcelona, Spain. 13 May.

Alzwainy, F., Mohammed, I., & Raheem, S. (2016). Application Project Management Methodology in Construction Sector: Review. *International Journal of Scientific and Engineering Research,* Vol. 7(3), pp. 244-253.

Archer, S. & Kaufman, C. (2013). Accelerating outcomes with a hybrid approach within a waterfall environment. *PMI® Global Congress 2013.* Project Management Institute. New Orleans. 29 October

Assaf, S. A. & Al-Hejji, S. (2006). Causes of delay in large construction projects, *International Journal of Project Management*, Vol. 24(4), pp. 349-357.

Bernard, H.R. (2011). *Research Methods in Anthropology 5th edition.* AltaMira Press.
Bollen, K.A. & Barb, K.H. (1981). Pearson's R and Coarsely Categorized Measures, *American Sociological Review Journal,* Vol. 46(2), pp. 232-239.

Brown, A.S. (2005). The charter: selling your project. *PMI® Global Congress 2005.* Project Management Institute. North America Toronto, Ontario, Canada. 13 September.

Bowie, J. (2003). Customer-driven project management: integrating the customer into the project. *PMI® Global Congress 2003.* Project Management Institute. Maryland, 25 September.

Chan, D.W.M. & Kumaraswamy, M.M. (2002). Compressing Construction Durations : Lessons Learned from Hong Kong building Projects, International Journal of Project Management, Vol. 20, pp. 23-35.

Choi, J., Peters, M.L., & Mueller, R. O. (2010). Correlational analysis of ordinal data: From Pearson's r to Bayesian polychoric correlation, *Asia Pacific Education Review Journal*, Vol. 11(4), pp. 459-466.

Choma, A.A. (2008). How to reduce risks in contractors' management. *PMI® Global Congress 2008*. Project Management Institute. North America, Denver. 19 October.

Collyer, S., Warren, C. M. J., Hemsley, B., & Stevens, C. (2010). Aim fire aim—project planning styles in dynamic environments. *PMI® Research Conference: Defining the Future of Project Management.* Project Management Institute. Washington DC. 14 July.

Cornelius, D. A. (2014). The PM role in a lean and agile world. *PMI® Global Congress 2014*. Project Management Institute. Phoenix. 26 October.

Deemer, P., Benefield, G., Larman, C. & Vodde, B. (n.d). *The Scrum Primer* [online]. [Accessed 7 November 2019]. Avilable at: http://scrumprimer.org/scrumprimer20.pdf

Diebold P., Ostberg JP., Wagner S., Zendler U. (2015) What Do Practitioners Vary in Using Scrum? Agile Processes in Software Engineering and Extreme Programming, *International Conference on Agile Software Development,* [online] 25-29 May. Helsinki. [Accessed 18 November 2019]. Available at: https://link.springer.com/chapter/10.1007/978-3-319-18612-2_4

Duggal, J. (2018). *The DNA of Strategy Execution Next- Generation Project Management and PMO.* New Jersey: John Wiley & Sons, Inc.

Ellis, A. (2013). *PMP exam simplified, 5th edition.* Colorado: AME Group Inc.

Fair, J. (2012). Agile versus Waterfall: approach is right for my ERP project*? PMI® Global Congress 2012—EMEA*. Project Management Institute. Marsailles. 9 May.

Fitsilis P. (2008) Comparing PMBOK and Agile Project Management software development processes. *In: Sobh T. (eds) Advances in Computer and Information Sciences and Engineering* [online]. [Accessed 17 July 2019]. Available at: https://link.springer.com/chapter/10.1007/978-1-4020-8741-7_68

Flick, U. (2011). *Introducing research methodology: A beginner's guide to doing a research project*. London: SAGE Publications Ltd.

Ganis, M. (n.d). *Agile Methods : Fact or Fiction* [online]. [Accessed 7 July 2019]. Available at: https://tcf.pages.tcnj.edu/files/2013/12/ganis-tcf2010.pdf

Grant, L. A. (2009). Lessons learned—do it early, do it often. *PMI® Global Congress 2009.* Project Management Institute. Florida. 13 October.

Guler, N. &Uyanik, G.K. (2013). A Study on Multiple Linear Regression Analysis, *Procedia - Social and Behavioral Sciences,* Vol. 106, pp. 234-240.

Huck, S. W. (2007). *Reading Statistics and Research*. USA: Allyn & Bacon.
Hunsberger, K. (2011). Change is good. *PM Network*, [online]. Vol. 25(2). [Accessed 17 November 2019]. Available at: https://www.pmi.org/learning/library/scope-creep-agile-methodology-scrum-4336

Hwang, B, G., Zhao, X., &Goh, K, J. (2014). Investigating the client-related rework in building projects: The case of Singapore, *International Journal of Project Management,* Vol. 32(4), pp. 698-708.

Idowu, O.M. (2016). Positivism versus Interpretivism: Fire-war on the Methodological Approach in the Study of Organisational Culture, *International Journal of Human Resource Studies, Vol. 6(4), pp. 178-187.*

Jarkas, A.M. & Haupt, T. C. (2015). Major construction risk factors considered by general contractors in Qatar, *Journal of Engineering Design and Technology*, Vol. 13(1), pp. 165-194.

Jin, C. (2017). *Agile in Construction projects.* Master Dissertation. Harrisburg University of Science and Technology.

Kendall, M. & Gibbons, J.D. (1990). *Rank Correlation Methods, 5th edn.*. Oxford: Oxford University Press.

Kerzner, H. (2003). *PROJECT MANAGEMENT A Systems Approach to Planning, Scheduling, and Controlling.* New Jersey:John Wiley & Sons, Inc.

Lavrakas, P.J. (2008). *Encylopedia of Survey Research Methods.* London: Sage Publications, Inc.

Lechler, T. & Gao, T. (2012). Explaining project success with client expectation alignment: an empirical study. *PMI® Research and Education Conference.* Project Management Institute. Munster, Ireland. 18 July.

Liu, Y. (2018). *SCRUM IN CONSTRUCTION INDUSTRY TO IMPROVE PROJECT PERFORMANCE IN DESIGN* PHASE. Maser Thesis. Harrisburg University of Science and Technology.

Lukas, J.A. & Clare, R. (2011). Top 10 mistakes made in managing project risks. *PMI® Global Congress 2011*. Project Management Institute. North America, Dallas, TX. 22 October.

Mack, L. (2010). The Philosophical Underpinnings of Educational Research, *Polyglossiah Journal,* Vol. 19, pp. 5-11.

Mahalakshmi, M & Sundararajan, M. (2013). Traditional SDLC Vs Scrum Methodology-A Comparative Study, *International Journal of Emerging Technology and Advanced Engineering*, Vol.3(6), pp.192-196.

Mastropasqua, F. (2018). *The Ultimate Guide to the Sprint Backlog.* [blog entry] [Accessed 24 July 2019]. Available at: https://www.clearlyagileinc.com/agile-blog/the-ultimate-guide-to-the-sprint-backlog

Meyer, D. (2013). *8 Steps To a Definition of Done in Jira.* [blog entry]. [Accessed 23 July 2019]. Available at: https://www.atlassian.com/blog/jira-software/8-steps-to-a-definition-of-done-in-jira

Mitchell, I. (2017). *Walking Through a Definition of Done.* [blog entry]. [Accessed 28 October 2018]. Available at: https://www.scrum.org/resources/blog/walking-through-definition-done

MOSER, C. A. & KALTON, G. (1989). *Survey methods in social investigation*. New York: Routledge.

Mulcahy, R. (2013). *PMP® Exam Prep.* USA: RMC Publications.

Nassar, N.K. (2009). An integrated framework for evaluation of performance of construction projects. *PMI® Global Congress 2009*. Project Management Institute. Orlando. 13 October.

Nee, N. Y. (2010). Metrics for agile projects: finding the right tools for the job. *PMI® Global Congress 2010.* Project Management Institute. Washington DC. 12 October.
Noll, J., Razzak, A., Bass, J., & Beecham, S. (2017). A Study of the Scrum Master's Role. *Product-Focused Software Process Improvement: 18th International Conference* [online], November 29–December 1. Innsbruck, Austria, Proceedings (pp.307-323). Available at: https://www.researchgate.net/publication/320671721_A_Study_of_the_Scrum_Master's_Role

Nunnally, J. & Bernstein I. (1994). Psychometric theory. 3rd edn. New York: McGraw.

Obrutsky, S. (2016). *Comparison and contrast of project management methodologies PMBOK and SCRUM* [online]. Dissertation. Eastern Institute of Technology. [Accessed 23 August 2019]. Available at: https://www.researchgate.net/publication/305969672_Comparison_and_contrast_of_project_management_methodologies_PMBOK_and_SCRUM

O'Brien, J.J. (1975). Managing construction projects. *Project Management Quarterly* [online]. Vol. 6(1). [Accessed 13 November 2019]. Available at: https://www.pmi.org/learning/library/managing-construction-projects-major-roles-5776

Owen, R., Koskela, L., Henrich, G., & Codinhoto, R. (2006) Is Agile Project Management Applicable to Construction? *14th Annual Conference of the International Group for Lean Construction* [online]. The Ponteficia Catholic University of Chile. Chile. 25-27 July. University of Huddersfield. [Accessed 25 August 2019]. Available at: http://eprints.hud.ac.uk/id/eprint/25965/1/2006_IS_AGILE_PROJECT_MANAGEMENT_APPLICABLE_TO_IGLC14.pdf

Ozmen, E. (2013). Project management methodology (PMM): how can PMM serve organisations today? *PMI® Global Congress 2013—EMEA*. Istanbul. 24 April.

Pham, L. (2018). *Qualitative Approach to Research: A review of advantages and disadvantages of three paradigms: positivism, interpretivism and critical* inquiry. [online]. [Accessed 5 October 2019]. Available at: https://www.researchgate.net/publication/324486854_A_Review_of_key_paradigms_positivism_interpretivism_and_critical_inquiry

Project Management Institute. (2013). *A Guide to Project Management Body of Knowledge (PMBOK Guide) 5th edn*. Pennsylvania: Project Management Institute, Inc.

Puspasari, T.R. (2005). *Factors Causing The Poor Performance of Construction Project.* Master Dissertation. University of Technology in Malaysia.

Qualitative Research on Special Education Teacher Preparation. (2014). New York: Routledge.

Rad, N.K. & Turley, F. (2013). *The Scrum Master Training Manual: A Guide To Pass The PSM Exam.* Management Plaza

ROBINSON, J. (2010). *Triandis' Theory of Interpersonal Behaviour in understanding software piracy behaviour in the South African context.* Masters Dissertation, University of the Witwatersrand.

Rowe, S. F. & Sikes, S. (2006). Lessons learned: taking it to the next level. *PMI® Global Congress 2006*. Project Management Institute. Seattle

Rubin, K. (2018). *How Long Should Teams Spend in Sprint Planning*? [online]. [Accessed 4 November 2019] Available at: https://innolution.com/blog/how-long-should-teams-spend-in-sprint-planning

Rubin, K.S. (2013). Essential Scrum: *A Practical Guide To The Most Popular Agile Method*. USA: Mike Cohn & Ron Jeffries

Sallee, M. W., & Flood, J. T. (2012). Using qualitative research to bridge research, policy, and practice. *Theory Into Practice*, Vol. 51(2), pp.137-144.

Saunders, M.N., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students.* London: Pearson Education Limited.

Schwaber, K., Sutherland, J. (2017). *The Scrum Guide The Definitive Guide to Scrum: The Rules of the Game* [online]. [Accessed 28 July 2019]. Available at: https://www.scrumguides.org/docs/scrumguide/v2017/2017-Scrum-Guide-US.pdf#zoom=100

Scrum Alliance. (2015). *The 2015 State of Scrum Report.* [online]. [Accessed 15 December 2018]. Available at: https://www.scrumalliance.org/ScrumRedesignDEVSite/media/ScrumAllianceMedia/Files%20and%20PDFs/State%20of%20Scrum/Scrum-Alliance-State-of-Scrum-2015.pdf

Scrum Inc. (n.d). *About Scrum Inc.* [online]. [Accessed 20 July 2019]. Available at: https://www.scruminc.com/about-us/

Scrum.Org . (n.d). *What is Scrum?* [online]. [Accessed 20 July 2019]. Available at: https://www.scrum.org/resources/what-is-scrum

Shen, L.Y. (1996). Dynamic Approach for Construction Project Management. *CIB W89 1996 Beijing International Conference.* The Hong Kong Polytechnic University. Hong Kong. 21-24 October.

Shirazi, K. (n.d). *Positivism, its strengths and weaknesses and on what grounds will one support or reject this paradigm* [online] [Accessed 9 October 2019]. Available at: https://www.academia.edu/8384477/Strengths_And_Weaknesses_of_Positivist_Paradigm

Soiferman, L.K. (2010*). Compare and Contrast Inductive and Deductive Research Approaches* [online]. [Accessed 10 October 2019]. Available at: https://files.eric.ed.gov/fulltext/ED542066.pdf

Sliger, M. (2008). Agile project management and the PMBOK® guide. *PMI® Global Congress 2008*. Project Management Institute. Denver. 19 October.

Straçusser, G. (2015). Agile project management concepts applied to construction and other non-IT fields. *PMI® Global Congress 2015.* Project Management Institute. Orlando. 10 October.

Streule, T., Miserini, N., Bartlome, O., Klippel, M., & Garcia de Soto, B. (2016). Implementation of Scrum in the Construction Industry, *Journal of Procedia Engineering*. Vol. 169, pp. 269-276.

Sutherland, J. (2014). *Scrum The Art of Doing Twice the Work in Half the Time*. New York: Crown Publishing Group.

Sutherland, J. (n.d) *The Scrum Papers: Nut, Bolts, and Origins of an Agile Framework* [online]. [Accessed 27 July 2019] Available at: http://jeffsutherland.org/scrum/ScrumPapers.pdf

Sverrisdottir, H., S., Ingason, H., T., & Jonasson, H., I. (2014). The Role of the Product Owner in Scrum-comparison between Theory and Practices. *Journal of Social and Behavioral Sciences,* Vol. 119, pp. 257-267.

Teijlingen, E.V. & Hundley, V. (2001). The importance of conducting and reporting pilot studies: the example of the Scottish Births Survey, *Journal of Advanced Nursing,* Vol. 34, pp. 289-295.

Tengan, C. & Aigbavboa, C. (2018). The Role of Monitoring and Evaluation in Construction Project Management. *Intelligent Human Systems Integration: Proceedings of the 1st International Conference on Intelligent Human Systems Integration IHSI 2018: Integrating People and Intelligent* Systems. 7-9 January. Dubai.

Theis, P. & Demir, S.T. (2016). Agile Design Management – the Application of Scrum in the Design Phase of Construction Projects. *24th Annual Conference of the International Group for Lean Construction* [online]. Boston. 19 July. [Accessed 17 August 2019].

Available at:
https://pdfs.semanticscholar.org/0bbb/26ddfbf92e71b6abf297858279a26d688032.pdf

Trevino, S. A. & Anantatmula, V. S. (2008). Capitalizing from past projects: the value of lessons learned. *PMI® Research Conference: Defining the Future of Project Management*. Project Management Institute. Warsaw. 16 July

Webster, F. M. (1994). Project management certification: the history. *PM Network* [online]. Vol. 8(11). [Accessed 17 September 2019]. Available at:

https://www.pmi.org/learning/library/project-management-certification-history-development-4941

Wideman, R.M. (1981). Managing project development for better results. *Project Management Quarterly* [online]. Vol. 12(3). [Accessed 17 October 2019]. Available at: https://www.pmi.org/learning/library/managing-project-development-phase-better-5753

WHITLEY, B. E. & Kite, M.E. (2018). *Principals of Research in Behavioral Science. 4th edn.* New York: Routledge.

Williams, C. (2007). Research Methods, *Journal of Business and Economic Research*, Vol. 5(3), pp. 65-72

Wilson, J. (2010). *Essentials of Business Research: A Guide to Doing Your Research Project*. London: Sage Publications.

Yang, J., B., & Wei, P., R. (2010). Causes of Delay in the Planning and Design Phases for Construction Projects, *Journal of Architectural Engineering*, Vol. 16(2), pp. 157-163

Appendix : Survey Questionnaire

Scrum in Construction Questionnaire

Participants' Demographics

1. Please Specify Your Gender

- [ ] Male
- [ ] Female

2. What is Your Educational Level?

- ○ High School
- ○ Bachelor
- ○ Masters
- ○ PHD
- ○ Other (please specify)

3. Which Field are You Working in?

- ○ Construction
- ○ IT Software Development
- ○ Education
- ○ Risk Management
- ○ Other (please specify)

4. Please Specify You Seniority Level Within Your Organization

- ○ Top Management
- ○ Middle Management
- ○ Junior Staff
- ○ Intern

5. How Many Years of Experience Do You Have in Project Management ?

- ○ 0-2
- ○ 2-5

- 5-10
- 10-15
- >15

6. How Many Years of Experience Do You Have in **Construction** Project Management ?

- 0-2
- 2-5
- 5-10
- 10-15
- >15

7. Do You Have Any Type of Experience or Knowledge Related to Agile Project Management Methodologies ?

- Yes
- No

8. Do You Have Any Type of or Knowledge Related to Scrum Specifically Within Your Field ?

- Yes
- No

9. How Many Years of Experience Do you Have in Applying Scrum Within Your Field ?

- 0-2
- 2-5
- 5-8
- 8-10
- >10

Section 2

Traditional Project Management Methodology Efficiency

This Section of the questionnaire is to verify the Efficiency of The Traditional Project Management Methodology in Managing Engineering

Projects (From Initiation until Closing) from an Engineering Consultant Point of View

10. Please select from the below the most appropriate answer. From an engineering consultant point of view, do you agree that managing engineering projects by utilizing the traditional project management methodology that represents the five process groups (Initiation, Design, Construction, Monitoring and Controlling, Closing) has many downfalls?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

11. Is one of the downfalls of the traditional project management methodology is that it lacks intense and proper client involvement in his project through all the process groups from initiation to closing?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

12. Is one of the downfalls of the traditional project management methodology is that it does not provide sufficient monitoring and controlling overall process groups in the project life cycle, specifically in the construction phase where there is enormous amount of activities?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

13. Is One of the downfalls of the traditional project management methodology is that it is rigid and static in nature where the construction industry in general is dynamic and its projects face a lot of changes and challenges ?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

14. Is one of the downfalls of the traditional project management methodology is that it lacks efficient documenting of lessons learned and most of this process happens in the closing phase instead of doing it often through the project life cycle?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Section 3

Scrum in Construction Questionnaire

Utilizing Scrum by Engineering Consultants in Different Processes in Construction Projects

This section is to examine the utilization of Scrum to manage engineering projects including the construction process from an engineering consultant point of view

15. In your opinion, what is the current status of Scrum in managing engineering projects from initiation to closing?

- Very Common
- Common
- Rarely Used
- Does Not Exist

16. A Project Manager: The person who in general, is responsible of the overall project and meeting the project's objectives successfully.

A Product Owner: in Scrum, the product owner is the only person responsible

for the success or failure of the product and boosting the product value.

From the above definitions, do you agree or disagree that the traditional project manager can fit as a product owner when utilizing Scrum framework?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

17. A Project Manager: A person who, in general, is responsible of the overall project and meeting the project's objectives successfully.

A Scrum Master: The person who ensures that Scrum is properly applied by the team, he acts as a coordinator between the team and the product owner and other stakeholders. He also coaches team members to ensure proper understanding of Scrum by all team members.

From the above definitions, do you agree or disagree that the traditional project manager can fit as a Scrum Master when utilizing Scrum framework?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

18. Knowing that the product owner role is as below:

1. Deep understanding of the project/product
2. Knowledge of all work that needs to be done within the project and document it in a product backlog
3. Proper and deep involvement in the project
4. Close interaction with the technical team
6. Responsible for the success of the project
7. Financing the project/Product

Do you think that a traditional project manager, as an **engineering consultant**, is capable of adopting and practicing the product owner role, **except financing a project**, while practicing Scrum to manage engineering projects from initiation until closing?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

19. Do you agree or disagree with the following definition: the product backlog is a document that gets prepared by the product owner, and can be considered as a base document for all the work that needs to be done or checked by the consultant in the project from initiation to closing. Each process group has its own product backlog where it acts as a WBS (Work Breakdown Structure) and clients' requirements register.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

20. The sprint backlog is a backlog that keeps team members focused on certain prioritized items from the product backlog within the sprint duration. Those prioritized items need to be accomplished in a certain sprint. Does this backlog supports the product owner and team members in staying focused on specific work scope that varies from one week to four weeks to avoid distractions, scoop creep and accomplish the required quality?

- Strongly agree
- Agree
- Neither agree nor disagree

- Disagree
- Strongly disagree

21. The daily scrum is a meeting that occurs daily and last maximum for 15 minutes. Does having this meeting in all process groups and especially during the construction process keep team members on track and keeps the product owner aware and updated of the progress and any possible risks?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

22. The sprint review meeting is a meeting that gets conducted after each sprint regardless if the sprint length is one week or four weeks. **Clients and key stakeholders** attend this meeting to review all accomplished work, inspect it and accept it (as an increment) if it meets their requirements. Would involving clients and key stakeholders in this meeting in all process groups and especially the construction process assist consultants and clients in eliminating/decreasing changes made by clients, understand clients' requirements and expectations and avoid scoop creep?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

23. The retrospective meeting is a meeting gets conducted after each sprint which acts as lessons learned and as a process improvement meeting. It keeps the process of documenting lessons learned fresh and effective for the project itself and other projects. Is it **more** effective than collecting and documenting lessons learned at the end of the project in the closing process?

- Strongly agree
- Agree

- Neither agree nor disagree
- Disagree
- Strongly disagree

24. The construction industry in general is considered as a dynamic industry. Construction projects are complex and face a lot of changes and therefore a flexible approach in managing it is needed instead of the rigid traditional project management methodology. Does having flexibility in managing construction projects through different process groups and intensive clients' involvement assist in dealing with changes and responding to risks?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

25. The Monitoring and Controlling aspect in any project is an important process that needs to exist in all other process groups. Would the iterative nature of scrum framework, daily scrum meeting, sprint review meetings and the retrospective meetings in the project's life cycle boosts monitoring and controlling and assist in meeting projects' objectives within budget and on schedule?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

26. The Scrum Burndown Chart is a visual measurement tool that shows the completed work per day against the projected rate of completion for the current project release. Its purpose is to enable that the project is on the track to deliver the expected solution within the desired schedule. Do you believe that the burndown chart is a great tool for monitoring and controlling and reporting the project status, especially at the construction process?

- Strongly agree
- Agree
- Neither agree nor disagree

- Disagree
- Strongly disagree

27. Eliminating/decreasing changes in construction projects can positively affect progress of projects and assist in completing projects on time and within budget. Would intensive clients' involvement in their projects, and intense monitoring and controlling on contractor's work ensure the compliance with client's requirements and decrease/eliminate changes requested by clients?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

28. In the initiation phase, two outputs are essential by the end of that phase, the project charter and stakeholder register. Would applying scrum in this phase encourage intense early clients' involvement, which could result in better understanding of the project by its client and clear requirements that is well understood by the product owner before entering the design phase?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

29. In the design phase when utilizing scrum, product owner, client and key stakeholders are intensively involved in this phase which assist in complying with clients' requirements at early stages and make any necessary changes before commencing in construction works. Would working closely with the client by applying Scrum result in a product backlog that act as a requirements tractability matrix?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree

- Strongly disagree

30. In the construction (Execution) process, and from an engineering consultant's point of view, would having a focused product backlog for each phase within the construction process (Excavation, Substructure, Superstructure…etc) and involving clients in this process to check and accept performed work as it gets done boosts monitoring and controlling, ensures meeting clients expectations and meeting the required quality criteria which eliminate/decrease changes and rework that may lead to delays and cost overrun?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

31. From an engineering consultant point of view, would utilizing scrum in the closing process create a clear path for both the consultant and the contractor of what should be done in this process by creating focused product backlog and intensively involve the client in this process to avoid distractions and conflict?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

32. Would intense clients' involvement in the closing process process assist in the handing over process and in understanding all used systems in the project by the client?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

33. From an engineering consultant point of view, would smooth and fast handing over and project closure mean early releasing of resources to be relocated to another project?

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

34. In your opinion, and from an engineering consultant point of view which from the below processes benefits the most by utilizing Scrum?

- Initiation
- Design (Planning)
- Construction (Execution)
- Monitoring and Controlling
- Closing