PROCESS QUALITY MANAGEMENT TOOLS WITH APPLICATIONS IN PROJECT MANAGEMENT

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ABSTRACT
Modern project management has expanded a lot, reaching for tools and techniques in other fields. Some of the tools currently in use while planning and controlling projects derive from production process management, and a lot of theories which originated in production, such as Six Sigma or the Theory of Constraints, have found forms in which they can be used in project management. The use of these tools, with some adaptation, leads to the improvement of the management processes encountered during the deployment of projects, rather than on the elements that contribute directly to their final product.

KEYWORDS: *process quality management; project management; quality assurance tools.*

JEL CLASSIFICATION: *M19, O22*

1. INTRODUCTION

Although project management became a science only about 60 years ago, concerns for the quality of project results have appeared much earlier. Ancient writers such as Herodotus (Herodotus, 1998), Plutarch, Diodorus of Sicily or Plutarh praise in their writings the accuracy with which the rock blocks that built the Egyptian pyramids were finished by cutting.
They also acknowledge the great pyramid of Giza was dressed at the end with polished stone, decorated with inscriptions, which turned it into a perfectly geometrical body with flat faces and lively edges. All this translates in time dedicated by the builders to end-work. We have to remember the fact that the pyramids were built for pharaohs of Egypt, so they had to be finished during their reign.
If we also take into account the fact that back then Egypt was a predominantly an agrarian kingdom, and that major construction projects could only be undertaken in a time window of about three months a year (otherwise people were busy sowing and reaping crops), we realize that time was a very valuable and very limited resource for Egyptian builders that built the pyramids. The fact that they have chosen to sacrifice part of that time to ensure the quality of materials and of the final construction, as mentioned above, is strong evidence that there were concerns regarding project quality even since antiquity. And the fact that their works have survived and are still admired today strengthens this conclusion.
Another early example of concerns for project quality assurance is the Parthenon in Athens.
The historical context was this: Greece was devastated by the Persian invasion of 481 BC, Athens was plundered and buildings on the Acropolis (fortified part of a settlement, situated on a hill) demolished. Under Athens a hundred Greek city-states have joined forces to push back the invaders. At a later time, Pericles, a military leader, took the initiative to restore the damaged parts of the city.

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Pericles' main objective was to build a magnificent temple to adorn the Acropolis, a symbol of the supremacy of Athens. The Athenians at that time considered that perfection meant symmetry. As a requirement included in the project plan, the Parthenon was to be a representation of this idea, a perfectly symmetrical building.

Pericles devised a human resource plan that would use both talented artists and unemployed Athenians, so that everyone could earn a living. This plan would take the unemployed off the streets where they would have begged normally, and also facilitate the Athenian economy by creating jobs and income for the entire population of the city. This was an important aspect of the project plan that helped it gain the acceptance of the Athenian public.

Transporting marble from the quarry to the construction site was the most significant project cost for Pericles. Workers cut 100,000 tons of marble, about 70,000 pieces that were transported 16 km to the Acropolis. This aspect was quite common in ancient projects; the same happened during the pyramids construction that we talked about earlier. Pericles' project began in 447 BC and was completed in nine years. Besides limestone foundation and ceiling and wooden doors, the temple was built entirely of marble - even the tiles were all marble.

Although the temple is, size-wise, the largest built, what really distinguishes it from other similar buildings is the quality and extent of its sculptures. Many of these sculptures were made from a more expensive marble, brought all the way from the island of Paros, famous at that time among sculptors for its raw materials. As a collection the Parthenon sculptures are simply unparalleled.

Parthenon has set the standard for large-scale projects that were to follow, and also for public works. What did Pericles was not only to create one of the most beautiful buildings ever built, but to establish the idea that it was possible to build aesthetically beautiful buildings without going over the project budget.

These aren't the only examples which confirm that concerns for quality assurance existed ever since the first major projects that we have historical evidence on. Over time this concern has taken scientific forms. Shortly after the establishment of management as science, quality has become a distinct field of study which led to the development of processes, ideas, theories and tools that have evolved themselves, adapting to changes that management ideas undertook. As such, when project management begun to manifest as a distinct science, ideas and tools from the quality field were taken and adapted to serve this new science

2. PRODUCT VS. PROCESS QUALITY

The classical approach to quality control was closely linked to the strategy and control of strategy ideas. According to those ideas, control may be financial (cost, sales, profit, investment incomes, income remaining after payment of loans, and so on) or non-financial (productivity, *product* quality, personnel, relationship with suppliers and customers, and so on). (Popa, Dobrin, Popescu, 2012)

Quality control has evolved from *final product* testing to ensuring the quality of the *processes* that create the product.

Today the **quality of a project** is defined in general terms by the extent to which a set of properties of the final product meets the standards set for them before the implementation of the project.

Project quality management is, therefore, a sum of processes necessary to ensure correspondence between the requirements the beneficiary set before starting the project and the final result.

It is widely recognized that there are two aspects of project quality management: one regarding project processes and the other regarding project deliverables. A failure to address both these aspects can have significant effects on product quality, customer and other project stakeholders' satisfaction and also on the organization developing the project as a whole. (Jiroveanu, Simion-Melinte, 2011)

Improving the quality therefore does not stop at the project's product - it also includes the processes used for obtaining it.

The Association for Project Management (APM) also believes that in addition to the result, the quality of a project is defined by the *processes through which this result is delivered to the project beneficiary*. (APM, 2011)
If we look back into history, we find that quality improvement never really stopped at the product, but always included the process by which the product is obtained. Evidence that the work processes were regarded with great respect is the proven existence of medieval guilds. These guilds imposed long periods of training for apprentices and those who wanted to become masters of their trade had to demonstrate skills. Such procedures were generally established to preserve and even increase the quality of work processes.
Taking into account the APM statement and the comments above, we will further analyze the main theories and tools that had, over time, affected the quality of planning processes and of those through which project deliverables are obtained.

3. MODERN THEORIES ON PROJECT PROCESSES QUALITY

Among the latest trends that marked the term “quality” and project management we will count two, the most recent ones, namely **Six Sigma** and the **Theory of Constraints**, because of the impact that they had and of the role they will play in demonstrating the point we are trying to make.
Six Sigma is a methodology that helps companies to dramatically improve results by designing and monitoring processes and resources so as to minimize losses and increase customer satisfaction. It guides companies to make fewer mistakes in everything they undertake - from filing an order to building a spacecraft – by eliminating mistakes at the earliest possible appearance. Quality control programs have focused on identifying and correcting industrial, commercial and design defects. Six Sigma covers something more than that: it provides specific methods to redesign the process so that defects and errors do not occur nearly at all.
From a simple quality measurement tool, Six Sigma has evolved to an entire strategy meant to accelerate improvements and to achieve performance levels unattainable before by focusing on features essential to the consumers and by identifying and eliminating causes of errors and defects in processes (Martin, 2008). The Six Sigma approach aims to reduce defects to only a few parts per million for products and key processes of an organization. Achieving such an ambitious task requires effective implementation of statistical principles and various quality tools for diagnosing problems and easing improvement.
Although there are differences in the way companies are choosing to standardize these processes at company level there is a clear pattern, which allows application of Six Sigma methodology for improvement.
Therefore, even if every project has, by definition, a unique result, it contains certain repetitive processes, standardized in most companies, especially those working in construction. All of them can benefit from the improvements proposed by Six Sigma.
Histograms, Pareto charts and control charts which we'll talk about later became tools for quality control in project management once Six Sigma begun its ascension.
The **Theory of Constraints**, which is actually one of the premises this cycle of articles is based on, was introduced by Dr. Eliyahu Goldratt in 1984 in his book “The Goal” (Goldratt, Cox, 2004). The simple idea behind it is that any system or process that takes place within companies is limited in reaching its objectives by at least one constraint, which may take the form of a piece of equipment or a department or a specific person (we refer to involvement in these processes of individuals with insufficient training). Once the company becomes aware of the constraint or constraints which limit its processes, it may make its first steps towards improvement and better achievement of its objectives. In project management, the theory of constraints generated a new trend, namely a planning technique based on **critical chain**, an alternative to the critical path which corrects its deficiencies.

4. MODERN PROJECT MANAGEMENT QUALITY INSTRUMENTS

The theories we presented previously, and many others, of which only some have found applications in project management, resulted in the development of a number of tools. We will analyze below only those that have found some utility in quality assurance in projects.

4.1 Gantt chart

The first such instrument is the **Gantt chart**, developed by Henry Gantt in 1917. At the time, this graph was a radical innovation, successfully implemented during the First World War (Radu, 2008). Using a Gantt chart led to increased project planning quality and a greater ease of communication within projects. Even if it is a relatively old tool, it is still used in modern project planning software instruments such as MS Project, Primavera, Spider, and others.

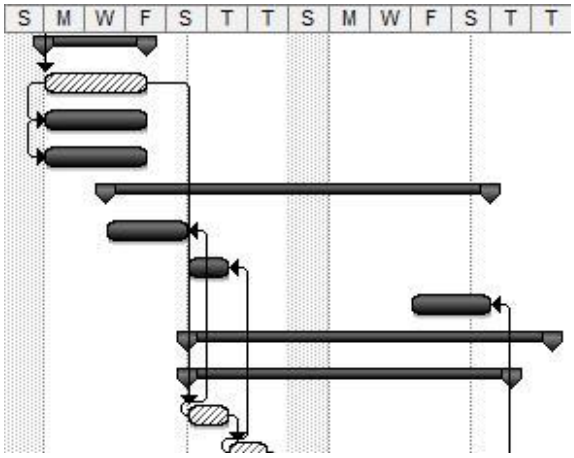

Figure 1 – Sample of a Gantt Chart

4.2 Brainstorming

Another tool that has increased the quality of project management, although it wasn't designed for that, is **brainstorming**.
Brainstorming was developed in 1939 by Alex Osborn, an advertising agency employee. Frustrated by the inability of his employers to come up with creative ideas for advertising campaigns, Osborn has devised a method of creative problem solving. He began to host sessions to generate ideas in groups, and noted that the result was much better than when people were thinking on their own. The quality of ideas generated was also much better.
According to Osborn, brainstorming is a *method by which a group tries to find a solution to a problem by collecting a list of spontaneously generated ideas* (Osborn, 1993).
The rules of brainstorming include encouraging strange ideas, generating a huge number of ideas in one session (based on the idea that a larger amount can produce more good ideas), and suggesting improvements to the ideas listed by the group members.
In project management, especially during project planning, brainstorming can bring major benefits, by encouraging team members to creatively solve problems they anticipate. However, given the strong points of project team members are usually well defined systems and processes, this approach which fosters free, almost chaotic thinking is often overlooked or not used at full capacity.

4.3 Ishikawa diagram

A derivative of the quality management in industrial production, which easily found its use in project management, is the **fishbone diagram**.

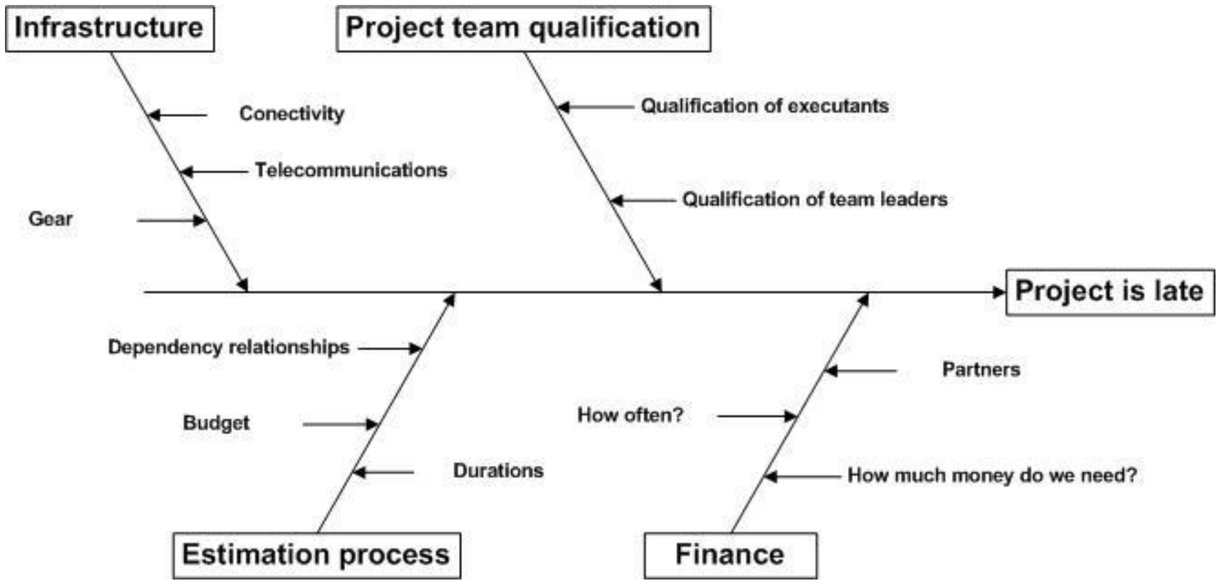

Figure 2 – Ishikawa diagram example used for identifying the causes for project lateness

Fishbone diagrams are often called "cause-effect diagrams" or Ishikawa diagrams, after Kaoru Ishikawa (1915-1989), a Japanese professor who has developed this technique in the 60s. The name "fishbone" comes from its shape. As shown in Figure 2, it is composed of a horizontal axis for building the map of factors that contribute to the final result (or problem which the team tries to elucidate).
The fishbone diagram is a tool often used in production processes to determine the causes of errors. It is also useful for improving business processes.
In project management fishbone diagrams are useful during the initial planning stage when gathering and organizing factors with impact on the project and also during project deployment when the project team faces various problems, anticipated or not.
In Figure 2, the problem whose causes are sought is the delay of the project. Notice that the main categories of factors are represented as "big bones" that flow from the central axis. Because the created diagram is just an example, it has been simplified. A normal Fishbone diagram contains at least six categories of factors. For a project, these categories may include: *legal causes* (unpaid contracts to suppliers who stopped the delivery of materials), *environmental causes* (for construction projects, a delay may occur due to bad weather), *communication problems*, *changes in project requirements*, and so on.
Thus, the "cause and effect" diagram is very useful in identifying hidden factors who keep resources blocked, lead to project delays or excessive consumption of resources. It is successfully used in project management as a planning tool. In this case, the "problem" is replaced by the project team with a desired effect and the "problem causes" are transformed into elements that help to achieve that effect.

4.4 Pareto chart

A very good tool that complements fishbone diagram is the **Pareto chart**. The principle which Vilfredo Pareto enounced in 1906 stated that about 80% of the land of Italy was owned by about 20% of the population. Over time this principle has suffered a series of adaptations, the one being used in project management today stating that *80% of problems are caused by 20% of causes*. Using recently developed tools (such as the Pareto chart), project teams can isolate some of the causes identified by the fishbone diagram and focus on their improvement, thus eliminating much of the negative effects without significant effort.

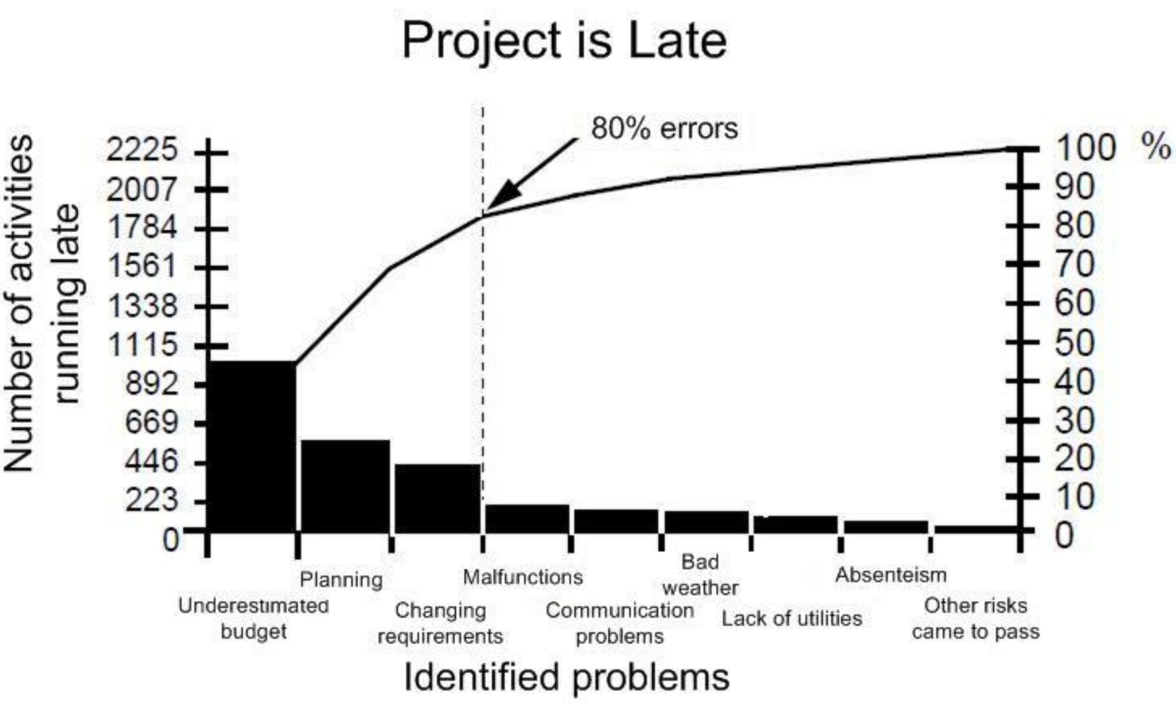

Figure 3 –Pareto Diagram
Source: adapted from Deac (2012, p. 388)

4.5 Control chart

Control charts were created by Walter A. Shewhart in the 20s, and they are the graphical view of process output over time (Pinto, 2007); they are still used to determine when the process is in control (when expected or random errors occur). Although usually used for monitoring repetitive tasks, they can be an excellent tool for cost and time control, and also for documentation errors that can occur in projects. Their application in project management at the moment is quite limited, and I consider that to be an error, since using a control chart to monitor a task that repetitively occurs during the project (such as a planned staff meeting or a masonry task for different levels of a constructed building) can be a great help to the project manager and his team.

4.6 Histogram

Histograms are graphs used in descriptive statistics. They show a frequency distribution. Frequency distribution refers to the number of statistical events that can be found in each of the classes (groups) of events.
Histogram origins can be found in a collection of writings of a famous statistician, Karl Pearson (Deac, 2012). He created around the year 1890 a graphic bar chart similar to that already used at the time, but different in its content: while a bar graph presents data from different categories, bundled as separate, unconnected bars, the histogram bars represent data from a single lot, for a considered period, which is measured in terms of frequency and intervals; so histogram bars are linked.
The main purpose of this tool is to graphically display the approximate distribution of statistical data that was collected.
As a visual aid it is a great tool which reduces large data sets into bars indicating peak levels or density distribution.
A resource histogram shows resource usage (number of hours or quantity) for each resource in the project during specific intervals (day/week/month).

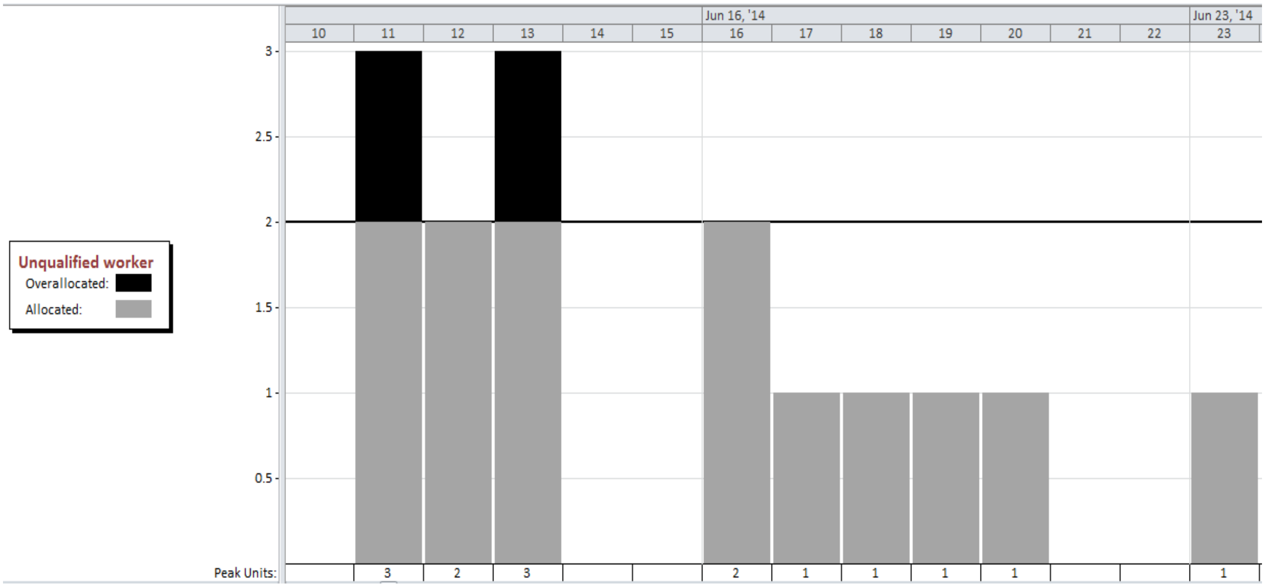

Figure 4 – Histogram

The histogram in Figure 4 shows the allocation of the “unqualified worker” resource in a project. It takes into account all the activities this resource is involved in at different points in time. Taking into account a work program of eight hours a day and the volume of work required to address all activities that require unqualified worker’s input, the histogram indicates that on 11th June and 13th June of 2014 the need for unqualified workers is greater than their availability (PMI, 2008). The tool also indicates how many additional workers we need to carry out all activities that require their input at the same time. From this point, the project manager decision is clear: he can either hire an additional number of workers for each of the periods analyzed (for example, he could employ 1 more worker in June) or to reschedule activities so they do not happen at the same time, thus reducing the need for workers on specific temporal intervals.
If the project manager has a budget big enough to enable the hiring of additional workers, he will do this, trying to finish the project faster. If there’s a budget constraint, however, or if work force is not currently available, the only solution is to reschedule tasks.

5. CONCLUSIONS

The tools and theories that I presented are all designed to improve the project management process, and they share credit for having brought it to the quality level where it got today. Even if most of them have been created for production purposes, a long time ago, their applications in project management are quite actual and in many cases still in need of implementation. Rethinking the planning technique, from the obsolete critical path, that only takes into consideration resource leveling within a single project, to the new, advanced critical chain philosophy that designs a way to level resources among a portfolio of projects sharing a common resource pool appears to be the next step in the endless pursuit for project management perfection, although it still stirs controversy in the scientific community.

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