MERGING THE SCIENTIFIC METHOD INTO THE PROJECT PLAN

Paper Number 4340

Peter J. Boden, Kenneth J. Puckett

Laser Product Safety, LLC, 3290A Green Level West Rd., Cary, NC, 27519, USA

Abstract

The success or failure of a project typically hinges on the application of sound project management fundamentals. Far too often, projects are not completed on time, within scope, and within budget since the process of managing the basic and critical elements of a project have not been clearly thought out, documented, and implemented. For engineering and technical projects, application of the scientific method should be embedded in the project plan as a task. This task is very often overlooked, and can be the cause of project failures, especially for those projects that are technical and deemed complex. This paper describes the use of a simple project management scheme, and how the scientific method can be embedded as a task in the project's execution phase. An example regarding laser safety and implementation of the scientific method is given.

Introduction

Experience shows that many engineers and scientists rarely follow defined scientific method (SM) steps. Possible reasons for this could be that education has failed to sufficiently teach the SM, complacency regarding adherence to and implementation of a scientific pattern for problem solving, and possibly lack of motivation and apathy. For whatever the reason, embedding the SM into the project plan will compel the task owner to put the method into practice, or at the very least, discuss its usefulness with the project manager and the team during the planning phase. With a successful project, it will become apparent regarding the promotion of embedding the SM into the project plan. The project team will see that the project was successful based upon use of the SM, and will undoubtedly embrace the need for its use in future projects.

Project Management

Complex engineering, scientific, design, and research projects often fail because of either nonexistent or poor application of the fundamentals of project management (PM). Project success is measured by whether it was completed on time, within scope, and within budget. A postmortem of any failing or failed project can typically point to a lack of implementation of sound PM. There are many reasons why projects fail including, but not limited to:

- Corporate culture does not truly accept PM.
- Lack of understanding that proper PM implementation will lead to success.
- Limited buy-in of the critical need of a sound PM plan.
- Lack of basic PM knowledge by the sponsor, stakeholders, task owners, and even the project manager.
- Limited stakeholder and sponsor engagement.
- Not empowering the project manager.
- Project plan not developed with input and agreement from the sponsor, stakeholders, and chief task holders.
- Limited knowledge, training, and ability to properly manipulate dedicated PM software.
- Lack of stage gate review driven into the plan.
- Not embedding a dedicated scientific method task into the project plan.

Implementation of PM fundamentals results in accountability for the sponsor, stakeholders, project manager, and task owners alike. Implementation of PM means that those involved with the project at the highest, intermediate, and lowest levels of responsibility are held accountable by the agreed upon project plan for project success or failure. In this regard in some corporate, governmental, and higher educational cultures, there can be a level of animosity and resentment toward the use of a project plan that shows the associated task owner's responsibility for delivery and on-time performance.

"Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Project management is accomplished through the application and integration of the project management process of initiation, planning, executing, monitoring, controlling and closing. The project manager is the person responsible for accomplishing the project objectives" [1]. In other words, the project manager is responsible that the project is completed on time, within scope, and within budget. These are known as the triple constraints, and their relationship is that if one constraint changes, at least one of the other constraints is likely to be affected.

In its simplest form, PM is managing all the elements of a project leading to success. If the project sponsor, stakeholders, and task owners are not familiar with specific and dedicated PM software to be used, then this could be a warning to the project manager that the project may not go as smoothly as initially anticipated. Unfamiliarity with the defined project management software platform by the team is one critical signal that the project manager must address.

Microsoft® (MS) Project, for example, is a dedicated project management software tool and includes modules for project work and project teams, schedules and finances, resourcing, budget management, report forms, data exchange, and other PM tools. MS Project and other dedicated and proprietary PM software, takes some level of training and familiarity to successfully drive and operate these types of platforms.

The role of the project manager is to develop the project master plan and ensure that it gets implemented successfully so that the triple constraints are met. It is vital that the project manager drives buy-in of the plan from the sponsor and chief stakeholders. This can be accomplished by developing a simple yet effective project plan scheme.

In the case where the project manager has determined that the project team is not familiar with, or does not have the time resource to adequately study and learn at some appropriate level the dedicated PM software platform to be used, then consideration should be given to using, for example, well-known MS Excel and MS Word to create a simple, yet effective project management scheme. The concept is to use a simplified PM scheme until such time the project manager and the organization feels comfortable moving toward a more sophisticated level of project management by using dedicated PM software.

The Gantt chart is the fundamental tool used to manage a project, and an Excel spreadsheet can easily be used to develop an effective project plan architecture. For example, the top rows of the chart (spreadsheet project plan) can show the project name, start and finish dates, sponsor, chief stakeholders, project manager, and the like. Beneath this information, the project timeline (baseline) can be shown within a row having column headings in months, weeks, days, or whatever interval fits the needs of the project.

The Gantt chart can then be structured with four critical phases each embedded with stakeholder stage gate review shown in the far left column having separate rows with subheadings of initiation, planning, execution, and close-out with baselines. This is where color coding of the Gantt chart becomes critical. The project manager can choose various colors to distinguish baselines, phases, stage gate review tasks, technical tasks, milestones, etc. Task dependencies can also be shown using a color coding scheme, graphic arrows, or just text to indicate whether tasks should be done in series or in parallel.

The project manager can easily build tasks in separate rows under each phase showing the name of tasks and other specifics as deemed necessary. Columns to the right of the tasks can be titled to show the approximate percent of the task completed (0, 25, 50, 75, 100 percent), and task owners. Again, the project manager can construct the plan using any number of colors which should be shown in a key on the project plan. The project manager can make effective use of inserting comments distinguished by carrots for any task, and along any baseline for the project phases. The comment carrots can also be used to distinguish milestones. A typical color coding can include blue for the baseline, black for task completed, yellow for caution, and red for task stoppage needing stakeholder and possibly sponsor intervention.

The project manager can develop MS Word documents to support the Gantt chart project plan. Documents can be developed such as the project Charter, Change Request, Budget, Resource Allocation, Status Reports, Stage Gate Review Model, Dashboard, and others critical to the project. These documents, and especially the Status Report and Dashboard are critical for high-level communication by the project manager to the organization, sponsor, and stakeholders.

Regardless of what type of software is used to manage engineering, scientific, design, or research projects, thought should be given to embedding a dedicated task in the execution phase with regard to the scientific method.

The Scientific Method

A scientific method (SM) in its most basic form is any method that applies a logic of effective thinking based on fundamentals to solve a specific problem, or set of problems.

There are a number of important processes that can be embedded into a project plan as a task. Regarding technical projects, one of these often overlooked is embedding a specific scientific method as a task into the project's planning and execution phases. This task when methodically followed, will eliminate much ambiguity in method, results, conclusions, and recommendations to the sponsor and stakeholders.

The SM has been called by many names including method of inquiry, experimental method, method of discovery, scientific investigation, and research method, among others. Application of the SM is not restrictive, rather it encourages creativity, innovation, problem solving, challenge of the solution, conclusions and recommendations. The core of the SM resides on three pillars: observation, measurement, and analysis of results.

Project management theory and the scientific method is nothing new. What is new as proposed in this paper, is the philosophy that the SM should be driven as a critical discussion point during the planning phase, and that the project manager is responsible for driving this discussion. In almost all cases, the results of these discussions will be the embedding of a dedicated SM task into the execution phase of the project.

The SM can be thought of as a method or process to follow to solve a problem. It organizes, and clarifies thoughts and moves in a direction to ensure that the project is successful by limiting scope creep, and wandering within the principal technical tasks. In many cases, project plans used for developing products, standards, regulations, and conducting research in some way implement the basic steps of the SM. However, most project plans do not include the definitive steps of such in the execution phase.

The scientific method will initially seem complex in its nature, but as one studies its pattern, it becomes obvious that it is quite simplistic in its objective approach. It is not only an effective tool that can be used by engineers, scientists, designers, and researchers, but can be applied to almost any field including education, economics, and the like. It is a straightforward and simple guide to ensure that basic and critical questions to be answered are driven into the project plan.

One SM example is, The General Pattern of the Scientific Method, that is a well-defined process for problem originating, preventing, solving, and challenge of solution. It is just an improvement guide of the centuries-old, The Scientific Method, which is the basic method by which we refine, extend, and apply knowledge through problem origination, prevention, solution, and challenge of solution [2]. It includes a more defined breakdown of the steps including developing logical alternate solutions to solve the problem, and developing and challenging a hypothesis. It is up to the project manager with team consensus to determine how detailed the SM should be to meet the needs of the project plan.

The scientific method is the basic method by which we refine, extend, and apply knowledge in all fields through problem orientation, preventive solution, and challenge of solution. Human thought is not a random operation. Thus, in almost any complex human activity that is repeated over and over, one can safely assume that there will be patterns to the activity [2]. Embedding this method (construed as a set of operations) into a project management plan assures a higher confidence that complex projects will be completed on time, within budget, and within scope. The project's sponsor and stakeholders will be obliged to take notice, and the task owner will be obligated to follow and implement some level of the SM.

The scientific method has many advantages for being worked into a project plan. Some of these include:

- Serves as a guide to organization, direction, solution, challenge, action, recommendation.
- A general method not solely for engineers, scientists, designers, and researchers.
- Will not by itself accomplish results, rather it is useful as a guide.
- Serves as a directional finder to solve future problems.
- Flexible as it is not an absolute rigid process.

There are other problem solving methods, some more complex, some simpler. One is the Osborn-Parnes Process that includes defining only six steps. Regardless of which method is used as a problem solving tool, it should be designed into the project plan and it should be built on a basis of developing objective conclusions and recommendations for the project sponsor and stakeholders.

The chief steps of a scientific method include but are not specifically limited to:

- Defining the problem to be solved.
- Gathering and evaluating the evidence (e.g. review of literature, existing data, etc.).
- Defining the experiment.
- Conducting the experiment.
- Analyzing the data.
- Developing objective conclusions based on the data.
- Recommending action to stakeholders.

Bringing it Together

It is believed that there is still a considerable misunderstanding (or lack of knowledge) in the management of engineering, scientific, design, and research projects and embedding within the project a standardized approach to problem solving. This approach should not be vague, rather is should be clear, concise, and clearly understood in its purpose and reason to be in a project plan. A project manager who is responsible for such a project is engaging in "project scientific management" (PSM). PSM is not, however, considered to be a theoretical perfect blend of project management and the scientific method, rather, it is more than likely to be a blend to meet the needs and goals of the project leading to success. This is the combined application of PM and SM fundamentals into a project management scheme. In many cases, the manager of a technical project may not be trained in the specific field, so the use of the scientific method within the project plan is often overlooked.

Simply knowing how to perform and complete a project task successfully may not be enough, however. The scientific method helps with organizing problem-solving guidance techniques. Both top and mid-level managers should incorporate the SM into their internal operations, planning, decision making, research, and problem solving. In a top-down approach, an optimal way to accomplish this is to develop SM training programs for staff so that they become familiar with its purpose, use, and implementation. Policies can be developed and implemented to embed SM into technical projects, especially those that are deemed to be complex.

With many projects, the stakeholders and possibly the project managers have not been exposed to the scientific method, and the project manager will need to demonstrate that the method should be made part of the plan. In other words, the project manager will have to educate the stakeholders on the importance of embedding SM into the plan. The project manager with input from the team, should attempt to build into the project plan a logical pattern to eventually solve the problem.

An important recommendation for project managers is to study the scientific method prior to development of the project plan, and to share that knowledge during the planning phase with the sponsor, stakeholders, and team in an effort to develop concurrence that said task should be shown in the project's execution phase.

Example

Regarding laser safety and implementation of the scientific method, one abbreviated example shared here, is the investigation of a laser safety eye accident and application of ANSI Z136.1, Safe Use of Lasers.

Defining the problem to be solved – This is a first step in applying the scientific method. A critical question to be addressed is:
Was the injury to the eye an actual result of laser energy, or was the injury due to, say, corneal abrasion, infection or other causes, and how could this injury have been prevented (e.g. application of safety measures)?
Gathering the evidence - This could an on-site review, for example, of the laser laboratory where the accident took place, and informational/document review. This would include a determination of what, if any, safety procedures and policies were in place at the time of the accident, were they being followed, and was a safety training program in place for laser personnel, etc. It could also include review of the laser specifications and hazard class.
Defining and conducting the experiment – In this example of a laser eye injury, it could be practical to combine a few of the defined SM steps into one. The scope of the experiment would undoubtedly revolve around assessing the accident against the engineering and administrative controls of ANSI Z136.1. Conducting the experiment would involve evaluating (in this example) the laser laboratory and safety SOPs and policies against the Z136.1 engineering and

administrative safety controls, OSHA, and State regulations and requirements.

Analyzing the data – A detailed analysis would be conducted regarding the findings in previous steps above, and whether said requirements were implemented and followed.

Developing objective conclusions based on the findings – Developing the conclusions can be based upon answering a few basic questions:

- Was the accident the result of lack of, or inadequate safety SOPs, policy implementation, training, etc.? In other words, if adequate safety measures were in place (e.g. ANSI Z136.1) is it likely that the injury would have been prevented?
- Will any of the solutions make a difference, solve the problem, or improve the situation?
- Will the findings result in short-term and long-term problem mitigation?

Developing objective recommendations based on the findings – Recommendations need to clearly dovetail with the conclusions, and could include:

- What should be done including mitigation and implementation (safety SOPs, policies, training, OSHA, State, ANSI Z136.1, etc.).
- Benefits of hazard mitigation.
- Benefits for developing and implementing safety SOPs and policy documents.
- Benefits of a periodic review following implementation of the overall laser hazard mitigation policy.

References

[1] Project Management Institute (2004) A guide to the Project Management Body of Knowledge. Third Edition.

[2] Norman W. Edmund (1994) Edmund's Idea and Research Report on The General Pattern of the Scientific Method SM-14.

Meet The Authors

Peter J. Boden, is Director of Technology, Training, and Project Management for Laser Product Safety, LLC. He holds a MS in Biomedical Engineering from Northwestern University. He is nationally and internationally recognized in the field of optical radiation (laser, LED, ANSI Z136.1) safety, and as a promoter of said safety standards. He has numerous publications in the safety engineering and R&D arenas, and has been the recipient of many corporate and national awards. He served as a catalyst for the development of the IECEE CTL WG6 Photobiological Safety, and serves on the U.S. TAG TC76, and ASC Z136 committees. As an IECEE Assessor, he has assessed laser testing labs in Japan, Europe and in the U.S. He also serves as an ANSI Assessor. He has received prestigious awards from Underwriters Laboratories, Inc., and from the Society of Automotive Engineers for the management of complex safety engineering projects.

Kenneth J. Puckett (LSO) serves as President and CEO of Laser Product Safety, LLC. He is a U.S. and global recognized laser and LED safety expert, and currently serves on a number of ANSI ASC committees, U.S. TAG TC76, IECEE ETF11, IECEE ETF5-ECS/OSM-LUM, and many others. He holds a BS in Electrical Engineering from the University of North Carolina. Mr. Puckett is a recognized expert with laser and LED laboratory product safety testing, and as a technical instructor for laser hazard analysis. Most notably, he was invited to lecture on laser radiation hazard analysis and radiometric measurement by the Massachusetts Institute of Technology (MIT), Cambridge, MA. Mr. Puckett has extensive product testing and evaluation experience in the field of product safety for a broad range of product and equipment types. He founded the first optical radiation testing laboratory and laser certification program at Underwriters Laboratories Inc., where he served as Principal Engineer Laser Safety.