

LEAN CONSTRUCTION EDUCATION: BASIC MANAGEMENT FUNCTIONS WORKSHOP

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ABSTRACT

This paper aims to show that a five-day workshop designed to train young Engineers based on a teaching method inspired on the Toyota production system, are both very effective and highly significant. It develops seven Basic Functions of production management based firmly on the Lean Principles. The goal of the Basic Management Functions Workshop (BMFW) is to build in participants abilities in production management, a predictive capacity while carrying out tasks, a balance of workload, the identification of constraints and productivity. The above mentioned development is supplemented by project management tools such as cost control, progress monitoring, Lookahead and constraints analysis, all framed within the processes of planning, scheduling, analysis and monitoring of constraints and contract management. The overall goal is to increase the growth of the organization through a strictly people-based approach.

It allows a fast alignment of new employees in the company, since there is a strong commitment to individual growth and awareness of the principles of the Lean Construction System, with a strong emphasis on the Client, based on the principles of “maximizing value” and “minimizing waste”. Based on past experiences of the workshop as part of the learning process within the company, there is no doubting for the authors that it has been a complete success, and could even be the first step towards a breakthrough in construction-related teaching in Peru.

KEY WORDS

Lean, education, basic functions, Socratic method, feedback.

INTRODUCTION

Principles nine and ten of Toyota's working methods are: grow leaders who thoroughly understand the work, live the philosophy, and teach it to others; develop exceptional people and teams who follow your company's philosophy.(Liker and Meier 2006). These refer to the growth of leaders and how they align themselves with the work philosophy of the company. It is also important that leaders are keen to work in a team and commit themselves to convey and share their acquired knowledge with all the members of the organization. Attitude and a willingness to learn are even more important than the previously-acquired knowledge of new workers.

The Basic Management Functions Workshop (BMFW) uses the Socratic method, through which the participant is prompted, by his/her tutor to provide answers to

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questions arising from his/her own analysis and to use feedback as the main teaching tools, always bearing in mind that the hands-on approach is the best way to learn.

Thus, a real case was prepared meeting the necessary requirements to tackle each of the core ideas inherent in the management system. The driving ideas are the company's principles, allowing a better understanding of each of the processes within the management of a project. At the same time, the basic functions related to Lean Construction are developed in each of the stages of the workshop.

The results obtained from the three workshops carried out so far have been very encouraging.

DEVELOPMENT

Every Project has different areas of Support contributing to Production. In conjunction, these areas guarantee the best possible outcome for a project, both for the client and the company. It is key to constantly maintain the client-partner relationship, an essential principle of the Lean philosophy.

During the BMFW, the aim was to raise awareness among participants of the direct relationship between production, the different support areas and the client. The BMFW is a management workshop, and as such, all basics taught can be used in any area or specialization.

Essentially, a Basic Function, rather than a work principle or methodology, is a way of reasoning, a style of thinking present in each and every member of a work team, helping them to focus always on the same objective.

The BMFW focuses on the identification and development of basic functions by participants, in such a way that, after the workshop, they can apply the basic functions to their everyday life, thus increasing productivity and efficiency at work, regardless of their field of endeavor.

DESCRIPTION OF THE SEVEN BASIC MANAGEMENT FUNCTIONS

As mentioned above, the objective is to demonstrate to participants that the basic functions represent the reasoning process which will allow each to attain his or her optimal working performance. The seven basic functions, described below, are developed and/or consolidated in the BMFW. They are summary of the core functions that engineers implement while developing a project and, consequently, during their daily lives.

IDENTIFICATION OF TARGETS

The development of this function aims to focus on the attainment of an objective, without wasting resources or effort on irrelevant issues.

A clear example would be the teamwork in a project, since each member pursues the same goal, which is to complete the project before the deadline, thus guaranteeing the profit of the project and the total satisfaction of the client. Bearing this in mind, every area uses only the information it considers necessary in order for the full scope to be achieved and the work correctly orientated, focusing on specific issues that will allow optimal planned results to be obtained.

BALANCING OF RESOURCES

This basic function properly allocates the work load among the resources used, always ensuring the resources are available. Using Last Planner, a production engineer can schedule and balance resources more efficiently and with clearer criteria.

As part of the programming process, production engineers estimate team size according to needs in the field. The estimate is done through a repetitive process, through which the programmer analyzes different alternatives until the optimal and most efficient is found. This process is simulated in the BMFW through the programming of activities related to the project, taking into account several coherent considerations and restrictions.

CALCULATION AND ANALYSIS OF GAPS

This allows quantification and comparison of a given result versus a foreseen scenario, in order to understand the cause of the deviations and take timely corrective action. Under real conditions and in order to have a better understanding of the project status, gap analysis is performed comparing the actual results with those foreseen. However, the Project Directors and Managers need something more than positive or negative data (profit or loss). For this reason each gap, no matter whether positive or negative, is analyzed. If some entries are found to have extremely negative gaps, it is then necessary to optimize to the fullest resource allocation in these entries in order to minimize losses. If, on the other hand, there are positive gaps, understanding the cause will allow us to further optimize those activities, and so increase the benefit by adopting the same work procedures and/or methodologies on other fronts or in other sectors.

SEQUENCE ANALYSIS

This aims to discover the optimal design of a production system, taking into account the relationships, real conditions and technical factors of the processes which compromise it. It shows how important a detailed analysis of the construction process is, in order to carry out more realistic and reliable planning.

CONSTRAINT ANALYSIS

This allows identification of any impediment to the achievement of goals at a given moment. The purpose of this function is solely to detect each and every inherent constraint in the construction process.

Every production engineer knows that in order to execute planned activities, he must have the necessary resources and information at his disposal. He is therefore constantly analyzing constraints for the development of the construction process and guiding them towards the support areas. A proper constraint analysis allows the support areas to redress said restrictions on time and so maintain an ongoing production flow.

MONITORING OF CONSTRAINTS

The aim of this function is to ensure restrictions are redressed on the basis of a commitment to restriction analysis. Once the restrictions are established, it is important to understand that their monitoring is a key basic function which allows activities to continue.

CALCULATION OF RATIOS AND YIELDS

This function is aimed at calculating the resources and speed of progress necessary to execute the activities efficiently. Through the development and consolidation of the calculation of ratios and yields, the participant can estimate resources required for any activity within the scope of the project, as well as estimate real deadlines within which to perform such activities.

It represents one of the basic functions most widely used in the fulfillment of the project since, while the project goes ahead, the ratios obtained in each activity are simultaneously calculated and compared with the planned ratios similarly, the project will establish the speed obtained in the construction process and will allow corrective actions to be taken or the maintenance and optimization of results obtained. This calculation can be used to project the results and obtain the project balance, bearing in mind the real requirements of the work, and thus obtaining a more reliable projection.

Optimum performance is attained by using and mastering all the basic functions mentioned above, either independently or jointly. This in turn contributes to the building of management capacities in the participants.

BMFW DESIGN

In his didactic work (Tomaschewski 1966) clearly states and develops the teaching - learning process sorting rules, which conform a general rule for developing the educational process whether in school, factory or workshop. This rule attempts to focus on the formal aspect of the procedure rather than the relation circumstance, since the latter is not explicitly treated for the differential case of the adult; hence, it is understood as implicit within the general rule.

On the other hand, (Freire 1978) presents an innovative paradigm with respect to the sorting of a teaching process for adults. However, his position converges with Tomaschewski in the sense that the rule generalization prevails over the teaching theory in adults.

Taking into account all of the above, the BMFW was designed following the teaching paths for adults, concentrating in following seven key points⁴ with respect to the way adults learn:

- Adults should wake up a desire to learn, they resist when somebody simply tells them what to do. Therefore, the BMFW teaches and reinforces topics that motivate the participants, as those related to project management.
- Adults learn only what they think they should know, are practical, want to know “how can that information or course will help me in this moment?”; being this a workshop where activities related to their day-to-day are proposed, they feel they should make the most from this experience.
- Adults learn when they do things, this was the main reason for creating the workshop as it is. It was decided that having its participants put into practice the theoretical concepts and clear out every question as they appeared throughout the course of each stage was the best path to take.
- The learning function for adults centers around problems, and problems need to be realistic, the workshop considered this premise as a starting point and centered around the development of a real construction project, where a series of considerations should be taken into account for the development of its various stages.
- Adults learn better in an informal environment, dynamic group activities contribute to a good learning. Consequently, each stage is carried out in teams of four, presenting a friendly, informal environment that turns out being beneficial for the better understanding.

⁴ Alan W. Moore (1993), “Mejorando nuestra habilidad para capacitar”, Washington

- A variety of methods should be used to instruct adults, in this case the Socratic method (as explained later on) was chosen with positive results.
- Adults want alignment and guidance, not notes nor rigid marks, they are impatient with education formalism; yet, require knowing how they are doing in the workshop, reason for the tutors to offer as much feedback as possible during each stage.

Finally, based on theories and experiences of researches, it was concluded that the most efficient way of developing the workshop would be the one where participants would put into practice everything learnt: participating actively by doing, rather than passively by “hearing” and “watching”.

Table 1: Percent retention of the participant according to the activity learning level.

The person assimilates:	
From what he reads	10%
From what he listens	20%
From what he sees	30%
From what he sees and listens	50%
From what he sees, listens and does	80%

METHODOLOGY OF THE BASIC MANAGEMENT FUNCTIONS WORKSHOP

DEVELOPMENT OF A REAL PROJECT

The BMFW is based on a real construction project that covers a series of discussions, variations and limitations, allowing it to gain a level of complexity and difficulty normally present in a project.

It is important to mention that, although participants in the workshop will have already acquired knowledge and aptitudes due to past experience in different projects and/or jobs, this is not a restriction. On the contrary, it helps reinforce what has been learnt before while taking on board new concepts.

KEY ISSUES OF THE BMFW

The workshop is based on four main features. The first is the often-mentioned basic function, the second is the fact that the BMFW is based on the Lean philosophy, the third is the use of management tools used in the projects and the last (though not the least important) is the teaching methodology used.

As Figure 1 shows, those attending the workshop already possess a certain level of knowledge, and it is during the workshop that they gain a wide-ranging apprenticeship in the use of basic functions, management tools and Lean philosophy, all taught, within the framework of the BMFW, using the methodology that will be explained below. Finally, at the end of the workshop, the participant will have acquired the ideal knowledge, attitudes and culture to perform their duties under Lean philosophy. This statement is supported by the commentaries and results of surveys performed on its participants months after their participation.

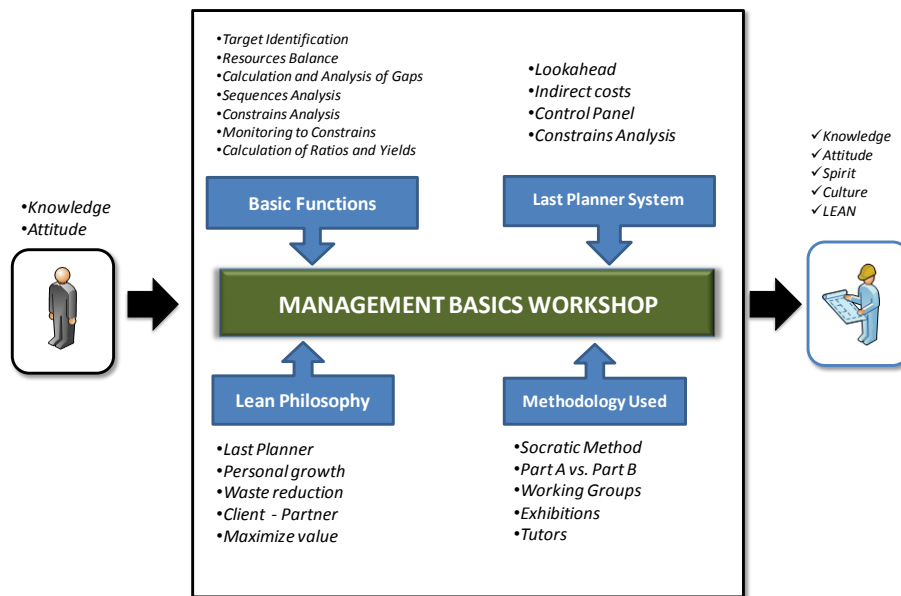


Figure 1: BMFW components

STRUCTURE OF THE MANAGEMENT BASICS WORKSHOP

The workshop is split into five days or stages; each focused on a specific management and/or control-related theme which is complemented by the others. However, by performing each stage individually, concepts are better understood and consolidated because something new is learned each day, reinforcing what was previously assimilated thanks to the thematic developed. Table 2 shows the breakdown of the BMFW stages and the basic functions developed in each.

Table 2: Relationship between each BMFW stage and basic management functions.

	Basic Management Functions
Stage 1: Reading of drawings and Cost Estimates	Target identification Sequence analysis Calculation and analysis of gaps
Stage 2: Calculation of ratios, gaps and yields	Target identification Calculation of ratios and yields
Stage 3: Programming and Resource Balance	Target identification Sequence analysis Resource balance
Stage 4: Restriction Analysis and Contract Management	Target identification Sequence analysis Constrains analysis Monitoring constraints
Stage 5: Progress and Cost Monitoring	Target identification Calculation and analysis of gaps

The order of the stages helps teach concepts steadily, starting with familiarization with the basic documents of any project, such as contracts, budget, drawings,

statements of work, among others. Then, the management process begins and ends with the implementation of project monitoring controls, such as monitoring of progress and cost control. This logically ordered structure helps all participants discover and strengthen their management capabilities, while also providing better understanding within the company.

DEVELOPMENT OF METHODOLOGY

The chart below (Figure 2) shows the methodology used in the BMFW, as well as capacities built up during its development, in order to consolidate the basic functions.

Management capacities to be developed during the BMFW focus on factors of social change within and outside projects. The workshop does not expect to turn participants into experts in the use of certain tools. Instead, the workshop plans to instill Lean principles which will be used both in peoples' professional and personal life.

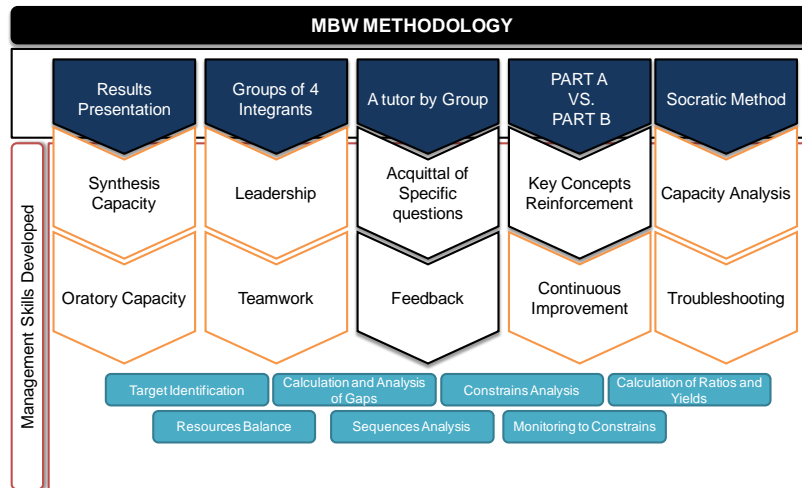


Figure 2: BMFW methodology

Groups within the workshop are monitored at all times and receive feedback from a tutor, who answers any question the group may have and provides feedback to point out mistakes made by the participants, while applying what they have learnt.

The use of four-member groups is relevant, since it contributes to better use of the interpersonal skills, such as leadership, communication and teamwork.

Each stage has two parts, A and B that strengthen the key concepts and expedite the ongoing improvement process. This is reflected throughout each part.

The presentation of the results obtained by each of the groups helps improve the knowledge acquired. Each member must be as concise as possible and present what he/she has learnt in the best way he/she can. Finally, by using the Socratic method, participants are prompted by their tutors to find out for themselves the answers to their queries. In doing so, a thorough analysis of the Model case is possible and participants can suggest different alternative solutions to the problems encountered, with the most suitable option being chosen.

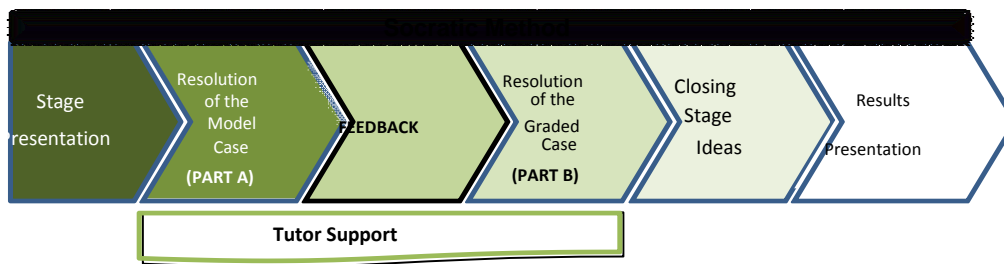


Figure 3: Development of the BMFW Stages

STAGE PRESENTATION

At the beginning of the workshop, the basic concepts are explained to ensure the participant's familiarity with the topics. The basic functions to be applied are also explained, to guarantee the understanding of the driving ideas. The presentation is totally interactive, using the Socratic method to build on the necessary concepts and then inviting everybody.

RESOLUTION OF THE FIRST EXERCISE (PART A)

Once this stage is presented to participants, the rules are explained so that the case can be tackled. Some requirements are explained and any questions posed are answered so that the activity is carried out in a clear and pedagogical way. The main objective of the model case is to allow participants at the BMFW to get to know the concepts, tools and working procedures required to develop this stage.

FEEDBACK

The instructor analyzes the answers and asks about the considerations taken into account to obtain a certain result. Later on, the instructor explains what went wrong and what could be improved in order to move on Part B. At this point, interaction between the instructor and participants is very important, as it raises the level of mutual understanding.

RESOLUTION OF THE GRADED EXERCISE (PART B)

When all doubts regarding the case study are explained, some additional circumstances are added to increase complexity.

By so doing, the driving ideas are consolidated, as well as the concepts of the basic functions used in the model case. However, it is important to get close to the right answer and/or result since, unlike the model case, this will be graded.

CLOSING STAGE IDEAS

Once the final feedback has been completed, the concept of the basic functions is reinforced once again, this time asking the participants to provide examples of when and how they have used the basic functions. Moreover, any query that arises during the session and that has not been explained in the previous stages is explained, thus contributing to enhance even further the quality of the workshop.

RESULTS PRESENTATION

Each group presents the results and the methodology used in front of the other participants. The goal of this stage is to analyze the ability of each participant to synthesize and present facts. On the other hand, it focuses on individuals showing their leadership skills, communication skills, teamwork and problem solving abilities.

Instructors then challenge the group with concept-related questions (related to the results already explained), or asking for explanations on how to apply what they have learnt in a real project.

PREVIOUS EXPERIENCES

The BMFW workshop has been carried out three times, attendances being 36, 60 and 64 successively. It was concluded that 60 was the optimal number of participants.

Once the workshop has taken place, all instructors meet to analyze the strengths and weaknesses of the workshop, and corrective measures are taken to improve forthcoming editions of the workshop, thus aiming for constant improvement.

Additionally, in special cases, BMFWs have been organized for small groups of workers as requested by the corresponding Management areas. This demonstrates its effectiveness and satisfaction by those who have participated in it and by their immediate superiors.

Each previous workshop has shown the potential of this teaching method to train and develop the personalities of both employees and teachers.

RESULTS

When the managers of those employees who participated in the BMFW were interviewed afterwards, it was clear that, according to their observations, the efficiency levels achieved by the workshop were very positive. “After attending the Workshop on Basic Functions, both the junior engineers and senior engineers were speaking the same language within the project”, confirmed Diana Abarca, Construction Manager of the National Theatre Project. She was referring to those engineers that had recently joined the company, since they all attained high levels of understanding regarding management issues related to the company, and used the basic functions to carry out their daily activities.

All showed a high level of understanding regarding management issues and stated that part of the success was due to the teaching methodology used (Socratic method + Instructor guidance + Feedback). Through this, a faster and more efficient alignment of new staff with the management system was achieved.

“The BMFW was more useful than my Graduate School studies. This is a very successful teaching methodology. I have never experienced anything like this”, said one Production Engineer, after he had participated in the workshop.

By the end of the BMFW, participants are asked to assess themselves, comparing what they previously knew to what they ended up knowing on management related issues after taking the workshop. Even though this is a predominantly subjective indicator, it is essential for identifying the participant’s personal perception of the BMFW as a whole, a key component for a workshop that besides imparting knowledge focuses on forming persons and transforming their attitude. So far, the results have been very encouraging, reaffirming comments like the one above and evidencing their willingness to adopt Lean philosophy into their rationale. Participants report that their management knowledge on issues tackled at the workshop increase by more than 130%, more than doubling their knowledge on management concepts, but most important of all, evidencing a positive impact on their attitude; thus, confirming the workshop’s success.

With regards to the Socratic method, all participants evaluated it as either superior (between 70% and 80%), or slightly superior (between 20% and 30%) to the traditional method of teaching.

Although these results show the perception of participants in relation to their own skills, it is an indicator of the approval level of the BMFW and the impact it has had on the people involved in it. Each of the participants, after self-assessing their knowledge, acknowledges the importance of participating in the workshop and the amount learnt having attended the workshop.

Results from surveys on participants months after taking the workshop show that they all understood significantly the management concepts applied by the company, and they acknowledge large part of the success to the teaching methodology used.

Table 3: Effectiveness evaluation of each method used in the workshop

Effectiveness of Method	Percentage
Feedback	80%
Socratic Method	73%
Case Study	76%
Part A vs. Part B	78%
Presentations and expositions	77%

Additionally, more than 80% of the surveyed stated that the BMFW allowed for a better understanding of the management concepts, and only a small percent said that this understanding was partially covered.

At the outset, the BMFW was aimed specifically at young and new engineers. However, this workshop works for both junior and senior engineers who are unaware of Lean philosophy.

An external workshop for senior engineers outside the company has been recently taught, yielding results that support the findings of the internal workshop. The results of the percentage of the twelve tutors surveyed who managed to increase their knowledge on each of the following management concepts after teaching the BMFW is shown below.

Table 4: Reinforcement of tutors' management concepts after teaching the BMFW

Management Concepts	Percentage of the 12 tutors who increased their knowledge
Advance Control	77%
Cost Control	85%
Planning and Programming	62%
Constraint Analysis	54%
Calculation and analysis of gaps	62%
Contractual Management	62%
Calculation of ratios and yields	54%

Asked if they thought it would be useful to introduce the workshop's teaching methodology in universities and/or grad schools, all twelve answered "yes."

CONCLUSIONS

Through qualitative analysis authors can conclude that the alignment time with the management system based on Lean principles, company values and organizational culture was drastically reduced with the BMFW. Thus, it was found that the best way to transmit on the Lean Construction philosophy to people was by means of developing real case studies, where basic management functions were applied.

Additionally, the BMFW allowed its participants to build up management capacities: the ability to work in teams, lead, present facts and findings, and synthesize and communicate results.

Furthermore, the BMFW has become a selection filter for future management talents, since each time the workshop takes place it grades both the objective and subjective standpoints. Consequently, it is possible to assess the aforementioned management capacities of each participant.

Taking into account the methodology used and the impact obtained, this teaching model has woken up the interest of different academic entities emerging as the first step to initiate conversations for including its topics in Civil Engineering under graduate and/or graduate syllabi. This demonstrates that the workshop goes beyond staff alignment, sharing knowledge that can be easily applied in the professional field. Its design allows for continuous update, and the ongoing improvement can be applied to the model case, whose complexity increases as the need arises, bearing in mind implementation and understanding of the seven management basic functions.

Lastly, the workshop provides a wider vision for each of the employees regarding the objectives of each of the activities they perform. One of the participants at the last BMFW stated the following: “Thank you for waking me up. I now understand perfectly well each of the processes carried out in my project”, which clearly shows his gratitude and personal satisfaction for all he had learnt at the workshop.

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