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JAMEA

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/jamea

e-ISSN : 2716-6201

Journal of Advanced Mechanical Engineering Applications

A Review of Problem Solving Techniques in Engineering Project Management - Mapping The Mind, Design Thinking Approach and Six Thinking Hats

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DOI: https://doi.org/10.30880/jamea.2021.02.01.003
Received 15 March, 2021; Accepted 23 June, 2021; Available online 02 August 2021

Abstract: In order to effectively manage and run a successful organization, problem-solving techniques are important for the successful leader/project manager. This paper introduced three problem-solving techniques in engineering project management which are Mapping the Mind, Design Thinking Approach, and Six Thinking Hats Methods. The objective of this paper is to review these three techniques, which consist of the descriptions of the techniques, the advantages/disadvantages, the highlights and the addition of suggestions, comments and analysis/comparison between the three techniques. This review had been made from various types of information, back in year 2000 until present which is year 2020. This article can be a good reference for engineering project managers, to be used by their project management team members, in order to solve associated problems during engineering processes or services.

Keywords: Problem solving techniques, engineering project management, mapping the mind, design thinking approach, six thinking hats

1. Introduction

By definition, the problem is a query to be measured, explained, or responded. In project management, the gap between the desired and existing condition was also can be considered as a problem. The activity to decrease the gap is called problem solving, whereby there are needs to solve the gap was obtained between the staff, the customer, the organization and the government. The barriers occurred between the use of technology for accomplishing the task also need to be observed as the problem. Besides that, the complexity of the problem faced by the project management team on a daily/monthly/yearly basis also needs to be monitored to diminish the effect. For instance, a team of Information Systems Development (ISD) needs to fully comprehend and solving the problems of a functioning system by monitoring the risk and finding solutions that evolving in processes related to ISD [1]. Furthermore, identifying the root cause of the problem also needs some attentions. The root causes of the problem had been identified under six dimensions of risk, by Wallace et al. (2004), which are team, organization environment, requirement, user, planning/control and complexity. It was found that these risks were influenced by the project scopes, and affecting the team performances by decreasing the development process quality [2]. Therefore, to solve the problem or gap, comprehensive problem-solving techniques were needed to be reviewed.

Hence, this article was made to explain, analyze and comprehend three types of problem-solving techniques, which are Mapping the Mind, Design Thinking Approach, and Six Thinking Hats Methods. The aim of this paper is to review these three techniques, which comprise the descriptions of the techniques, the advantages/disadvantages, the highlights and the addition of suggestions, comments and analysis/comparison between the three techniques. This review was made from various types of information, back in the year 2000 until 2020.

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2. Problem Solving Roles

As one of the engineering program outcomes, complex problem solving proficiency had become the main focus in accreditation requirements and outlines [3]. Complexity had been described as the dynamic condition, influenced by the interdependent variables that need a system to overview the process. This system was needed to identify the interconnections, dependencies, and boundaries that were influenced by many aspects. This system also must be able to rectify the problem and solve it efficiently [4]. Based on the stakeholders feedbacks, engineers are demanded to solve the complex problems, because they are considered as the competent technical person in charge, based on their profession and ability [5].

To achieve the success in problem solving, the engineer need to search varies way of solving techniques, and these techniques could be outside of typical boundaries [6]. Few criteria need to be mastered by the engineers in order to master these techniques, such as able to understand the problems, difficulty level, having the depth of knowledge required, effective in relating the concepts/skills/knowledge required to find the solution, and comprehending the degree of nonlinearity relations between the variables within the given gap boundaries [7]. If the problems are more complex with unlimited boundary, hence more opportunities of solution can be obtained. These conditions had typically occurred in the reality, whereby the problem's complexity extends beyond the knowledges obtain from schools/university syllabus and program design [8].

Engineers with the preeminent ability in problem solving and critical thinking were very marketable and needed by the 21st-century industries [9]. Through a survey made to 2,115 managers and executives conducted by the American Management Association (AMA) in tear 2010, the critical thinking skills were second in ranking as the most articulated skill priority in the organization, as well as in the most vital skill when signing fresh professional workers [10]. Current studies were consistent with this call for the needs to teach problem-solving skills. A study conducted in the year 2013 by the International Data Corporation (IDC), by analyzing 14.6 million job postings, to search for skill requirements in high-growth and high-wage jobs. The findings of this study categories the problem-solving skills as the "cross-functional", whereby this skill was being required by over 50% of the high-growth, high-wage positions reviews [11]. More research had been made in year 2015, based on the Educational Testing Service's (ETS) study, America's Skills Challenge [12]. They compared the America's 16–34-year-olds to their international counterparts, and the results found that the American's was rated 20th of 21 countries on problem-solving skill readiness. This information suggested, for more additional requirements on problem-solving activities such as the capacity to think creatively and integrate knowledge across several functional areas [13].

3. Problem-Solving Techniques

With the intention of efficiently manage and operate a successful project management group, the project engineers must lead their subordinates and mastering the problem-solving techniques. Discovering an appropriate solution can be accomplished by using the established and available problem-solving techniques. In this section, three creative problem-solving techniques were reviewed, which are Mapping the Mind, Design Thinking Approach, and Six Thinking Hats Methods. Project engineers encourage to learn and adapt to these problem solving techniques, hence bringing more profits to the company and success in their career.

3.1 Mapping The Mind

Project engineers usually used mind mapping as a method to visualize and generate ideas in problem solving, and communicate with their associates through the drawings either on paper, computer or smartphones. Mind mapping method or technique was developed in the context of Ausubel's learning theory. The main idea behind this method is to support meaningful learning, which relies on the new information that can be related to the existing information that already available. There are no wrong or right answers in mind mapping. Hence, there is an argument that mind mapping could sustenance creative problem solving. However, the benefits of information technology had aided the engineers and their project team members to produce creative problem solving, and this activity usually happened through the knowledge activation phase of the search for ideas, by broadening the set of associations that can serve as the basic foundation for creating the solutions [14]. For example, during a discussion session, the anticipation to draw the mind map will encourage the engineers and their project team members to explore more information that beyond the typical solution. Moreover, one engineer's mind has a limited capacity of working memory. By creating a mind map with the team members, it can work as a reminder of the knowledge that can be recalled on a long-term basis. Previous findings from researchers had proven that the activation of relevant knowledge had led to more new ideas, as a result of a more persistent search for ideas within the prior activated knowledge structures [15]. However, because of this problem solving technique offer limited individual inspiration and less accessible exploration, the engineers that were expert in information technology could become more dominant in expressing the ideas via the depth of the exploration. This condition will affect the extensiveness of exploration, whereby it can be limited or nonexistent [16].

The good fact of this technique is it can mix up multiple list types of solutions and keeping track of the required task. It also helps the engineer to picture the complex jobs, and easy to explain during the project management presentation. However, the disadvantages of this technique is it was easy to over complicate and messing up the original ideas.

Sometimes the engineer will have some difficulties to elaborate the ideas. Moreover, it takes a longer time to generate an effective and flawless mind map. The example of an engineering mind map is shown in Fig. 1.

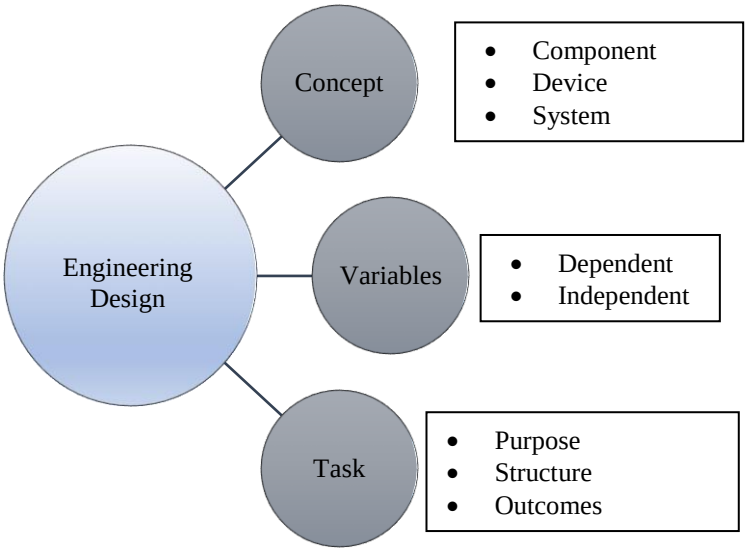

Fig. 1 - Example of engineering mind mapping

3.2 Design Thinking Approach

The project engineers use Design Thinking (DT) as the method to find a solution to a complex problem based on the end user feedback. This method evolved and became global. More industries were keen to manufacture their products and improve their processes through the extensive use of effective imagination, testing certain possibilities and follow their intuition [17]. By using DT, more good outcomes were obtained especially when the engineers deal with certain complex and vague problems that cannot be solved through conventional methods [18]. They solve their problems by comprehending the process and observe the problem directly. They need to apply this method because sometimes the customer feedback is not clearly explained during the interview or survey [19]. DT was the most effective solution in the corporate sector, because it is endless anticipating capability and adaptation through changes [20]. The general process of DT consists of the diamond approach to divergent and convergent thinking steps. The phase of divergent contains the exploration of user needs and empathy building, and the phase of convergent comprehend the solution generation [18]. Throughout the exploration and solution generation phases, lots of creative tools can be utilized to produce solutions. For instance, brainstorming can be used to choose the preeminent ideas [21].

Fig. 2 shows the DT's can be divided into six intertwined macros-phases. These micro- phases are not totally rigid or linear and can occur simultaneously or iteratively. If failure happens, the procedure can return to the previous steps. Some of these macro-phases are more intensive in end-user interactions. These phases are represented in Fig. 2 by circles 1, 2, and 6. The other steps, such as the ones represented by circles 3, 4, and 5, are carried out most of the time in the industry with minimum end-user interaction [18].

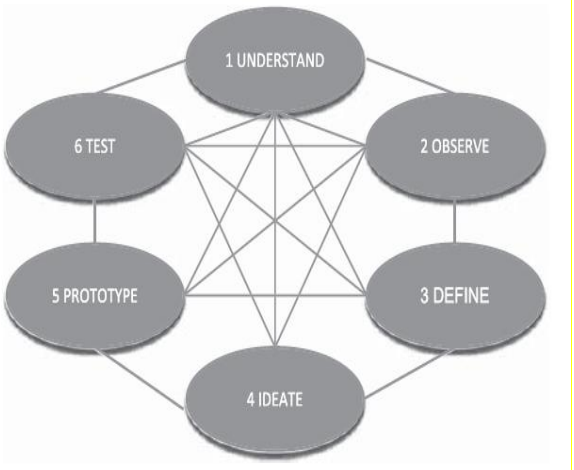

Fig. 2 - Main design thinking phases [18]

The advantage of the DT was it is easy to innovate the phases strategically and tactically. It can produce a creative, logical solution during the implementation, by transforming the information obtained from the industry towards an innovative outcome.

3.3 Six Thinking Hats

The Six Thinking Hats (STH) problem solving technique was proposed by the famous psychologist named Edward de Bono. This technique contains different thinking styles associated with analyzing a given problem effectively, whereby the six hats represent six different thinking styles used in a systematic problem-solving procedure with different approaches. Different color of the hat were conceptualized based on the individual focus on the style of thinking. Hence the problem can be scrutinized from a different side of views. STH supports lateral thinking possibilities and enables new solutions during problem-solving terms so that the best outcome can be extended. Each type of hat produces sufficient amounts of answers to any gaps based on neutral quantitative judgment, humanistic thinking, optimistic, creative, negative, or managerial thinking [22].

The STH functions by conceptualizing each type of hat color which associate with the person's style of thinking. For example, the white hat represents a person who accepts neutral judgment based on figures and facts. The red hat signifies humanistic thinking filled with emotions and feelings, and the yellow hat emphasis on the positive aspects of the condition. Black is a pessimist, green is creative and blue is managerial [23]. This technique of exploiting the ideal solutions, even though promising, but it is problematic or even unmanageable to achieve. However, it can be a good approach, if the ideal solution to any problem in any system, did not consume any material resource and time while executing this method [24]. The summary of this method can express through Table 1 and Table 2. Table 1 presents the STH styles and roles and Table 2 shows the STH technique for different type of people and their critical situation types, respectively [25]. What are the disadvantages of using STH technique? Some users said that this process of thinking is very time-consuming. Sometimes, certain team-members prefer to think alone rather than in a group. Conflicts can still ascend between project team members of different perspective.

4. Conclusion

In the end, the problem-solving tools and skills are required for the project manager position in recent management condition. Organizations seek creative ideas to cope with dynamic and turbulent business environments and continuously changing customer demands. This article had presented the based outline of three problems solving techniques, which are Mapping the Mind, Design Thinking Approach, and Six Thinking Hats Methods. This review can be a good reference for engineering project managers, to be used by their project management team members, in order to solve associated problems during engineering processes or services.

Table 1 - Six thinking hats styles and roles [25]

No.	Thinking Hat	Roles of thinking hat
1	White Neutral Hat	White Neutral hat relies on facts, data, statistics and concrete information for solutions to problems.
2	Red Intuitive Hat	Red Intuitive hat uses feelings, emotions, values, and intuition while finding appropriate solutions to the problems.
3	Yellow Optimistic Hat	This hat inspires to logically present positive plans of action that will help overcome the problems.
4	Black Pessimistic Hat	The black hat is characteristic of the negative and pessimistic approach. However, it is one of the most important styles of thinking as will help to better understand the pitfalls of thinking.
5	Green Creative Hat	Green Creative hat tends to bend the rules, think outside-the-box and expand the possibilities of the improbable in unique ways. The Green hat will come up with brilliant creative solutions — opening the doors to new opportunities and unique solutions.
6	Blue Managerial Hat	Blue Managerial hat uses managerial techniques to direct the thinking process.

Table 2 - Six thinking hats for different type of people and their critical situation types [25]

No.	Color of hats	Description	Type of People	Type of Critical situations
1	White	Quantitative thinking using facts & Figure	Administrator	Defeat
2	Red	Humanity based Thinking based on ethics, Values emotions & feelings	Sage /Religious leaders	Deprivation
3	Yellow	Optimistic Thinking based on hope, positive & speculative	Leader	Delay
4	Black	Negative thinking based on comments, critics, cautious & careful	Politician	Diplomacy
5	Green	Creative thinking based on ideas and lateral thinking	Innovator/ Scientist	Discovery
6	Blue	Managerial thinking based on planning, organizing and controlling aspects	Manager/ Executive	Danger

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