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Measurement System Analysis and System Thinking in Six Sigma:
How They Relate and How to Use Them

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ABSTRACT

This article investigated measurement system analysis and system thinking in Six Sigma, as well as the factors that influence these actions. If the measurement system being used to accumulate data from the process delivers dependable and accurate results, the measurement system analysis regulates it. Process improvement initiatives can be derailed by faulty measurement systems. Also, managers who have read faulty data can be misled into making wrong decisions. To collect trustworthy data, a reliable measurement system is established with this process. A method to assess an organization as a system and interpret its practices as a whole with Six Sigma is system thinking. Also, fixing a system as a whole helps to identify the real causes of issues and to know where to address them. This article addressed the contribution of these two methods to an overall success of an organization operating Six Sigma. The most current variables, concepts, and models were studied within operations and project management. By using a design-science-investigate strategy, this study approved of a valuable growth reveal for reasonable and hypothetical application. This study allowed us to generate a fitting assessment model that will fill the research void. Also, this study contributed to the engineering field with improved project success rates and team communication.

KEYWORDS

Improvement Initiatives, Measurement System Analysis, Six Sigma, System Thinking

INTRODUCTION

Since data is the driving force in today's society, it impacts everything in daily living. Data is used by organizations in millions of ways, such as collecting data in massive loads to measure and inspect. Since organizations base their decisions on measurements, they are important. Also, in any establishment, measurement systems are important. The quantification of specific characteristics is enabled by this system that relates measures. To validate a particular unit of measure, gages, software, and personnel are required. Measurement method, measurement process, measurement instruments, and reference standards are included in the system. Decisions regarding the services provided by an organization are based on measurement values. With unreliable measurements, mistakes and bad decisions are made. More accurate measurements mean fewer errors that will occur in future processes. To assure accurate data, processes have to be suitable to their application (Little, 2001; Galli, 2018c; Milner, 2016; Detert, 2000; Zelinka & Amadei, 2019).

However, measurement systems are from perfect, and there can never be a system completely free of error. There can be small errors that will be mostly insignificant and big errors that can be

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useless because they are unreliable. Process, such as a test method, personnel including operators and their skill level, equipment's gages and their calibrated system, items measured their sample plan, and environmental factors, such as temperature and humidity are different sources of variation.

A method of determining the amount variation that exists within a measurement process is measurement system analysis. The overall process variability is directly contributed by measurement process. The system's accuracy, precision, and stability are evaluated by the method that certifies the system based on its findings. Components of measurement system variation are outlined in Figure 1.

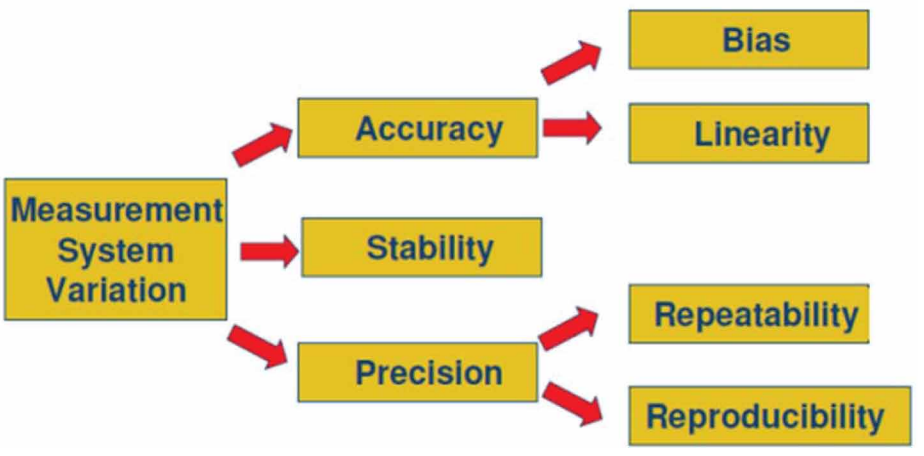
A methodology that helps to improve an organization's processes by using statistical analysis is Six Sigma by translating operational problems into statistical problems. To solve these problems and to transform the results into practical actions, statistical tools are used (Pourdehnad & Robinson, 2001; Andersen, 2014; Galli, 2018b; Loyd, 2016; Nikabadi & Hakaki, 2018). With a data-driven and greatly methodical approach, defects are eliminated. This method can be used on any organization process in any field. Also, to determine what can be defined as a Six Sigma defect, client specifications are used. Diminishing the inconsistencies in an organization processes is the target. To achieve true Six Sigma, 34 million opportunities is the maximum to be kept by organizational processes. Six Sigma is a business strategy that seeks to identify and eliminate causes of errors or defects-defined as anything that could lead to customer dissatisfaction (Azar, 2012; Antony, 2004; Al-Kadeem et al., 2017a; Galli, 2018a; Nabavi & Balochian, 2018). A very important reason why establishment of Six Sigma is significant is reducing defects.

To identify problem areas and recurring issues that affect quality expectation, employees use certain techniques. With proper training of Six Sigma, employees have the skills to identify problems that affect production or performance. In turn, this helps to identify areas for improvement and can be worked on continuously. With Six Sigma, the variations and waste that appear after improvement ideas can also be eliminated.

When the goal is to resolve a problem immediately, Six Sigma is best. Since its focus is closing in on problems in a project environment, there is no perspective of the bigger picture. Root causes are not the main focus, so the problems remain. Because of this, organizations and stakeholders are not fully satisfied because expectations of long-term solutions are not met. In order for Six Sigma to become fully satisfying, it must incorporate system analysis to get a broader perspective and develop long-term solutions.

With competition in the world continually increasing, organizations have been forced to adapt. Focusing on quality improvement and anticipating customer expectations is necessary. Furthermore,

Figure 1. Components of measurement systems



continually adjusting themselves and adapting to the feedback from the environment to improve the quality of their services is needed to thrive in today's market (Mole, 2004; Ahern, Leavy, & Byrne, 2014; Shenhar & Levy, 2007; Omamo, Rodriguez, & Muliaro, 2018). Thus, it is critical to implement system analysis, as focusing on systems as a whole help to identify the root of the problem and to prevent future complications.

There was a wealth of literature that showed the crucial role that these variables, their concepts, and models play in project management and performance. However, there was an evident gap in knowledge regarding how these variables, their concepts, and models enabled the smooth progression of project management and performance. This research stemmed from the knowledge gaps that existed within the related literature on these variables, their concepts, and models. The focus of this study was to evaluate the elements and applications of the most current these variables, their concepts, and models. The study sought to examine the overlaps and disparities of these variables, their concepts, and models to understand the differences and similarities between them. From there, this study sought to propose a framework that encompasses the best practices and elements of the current model to propose a "universal" framework for all forms of project, operations, and performance in all industries/ business sectors. The research focused on providing evidence-based answers to the primary questions that experts in these variables, their concepts, and models ask. For example, it was studied how to maximize on the expertise of these variables, their concepts, and models to achieve the goals and objectives of project management and performance. Additionally, the findings of the research provided a platform for building further research relating to these variables, their concepts, and models.

The current literature highlighted the gap in research. While there was a wealth of literature that showed the crucial role that these variables, their concepts, and models played in operations and project management, there was an evident gap of information on operations and project management. The focus of this study was to evaluate the elements and applications of the most current variables, their concepts, and models in the area of operations and project management. The study sought to examine the overlaps and disparities of variables, their concepts, and models in order to understand the differences and similarities between them.

Necessary decisions need to be made by every engineering manager, and this is only going to become more important in the future of both the project management and engineering professions. For the engineering management practitioner, this paper is critical. This paper provided a discussion on the future of these topics, how it fits into engineering management, and how engineering managers need to effectively account for this in their operations and project management lifecycle and different project management environments. Also, the paper discussed what the future of these topics and factors will look like and the role the engineering manager will play in that future; this research also outlined the relevance and contribution to the engineering management field. The study described and explained the critical implications of these findings at different organizational levels, including corporate level, managerial level, and project team level. The engineering management practitioner can use the conclusions of this study to improve capitalizing on these factors and relationships not only at different levels of their project environments, but also on operations.

This study's aim was to add to and expand upon literature that discusses the efficiency of these variables, their concepts, and models. It also evaluated the likenesses and differences between the assessment tools of these variables, their concepts, and models. Multiple studies that have tested this paper's hypotheses have been combined to contribute data to this paper.

Different research perspectives and ideas were adapted in this study to propose new solutions to current problems. The study and hypotheses of this study were explained. Firstly, it utilized a design-science-investigate strategy. Secondly, it approved a valuable growth reveal for reasonable and hypothetical application. Lastly, it created a suitable assessment model of these variables, their concepts, and models. While concentrating on evaluation instruments as a response to the examination question, this paper supplied an outline of development models. Additionally, there was a review of the evaluation instrument and an explanation about the outline's approach. The analysis featured an

outline of the consequences of the meetings, as well. The conclusion mentioned initial discoveries and suggestions that organize investigative limitations and plans for future studies.

Since this study made a substantial contribution to the limited amount of literature on applying these variables, their concepts, and models to project management and operations management, it also significantly contributed to the profession. The findings illustrated the advantages of using these variables, their concepts, and models, but it also showed its limitations when performance and sustainability are not considered. The true-to-life examples in this study demonstrated how important it is to apply these theories to real world situations. Practicing these variables, their concepts, and models is a sensible avenue for many businesses to use, and this study examined these subjects in both theory and practice.

Furthermore, this study concentrated on these different variables, their concepts, and models because pre-existing literature does not explore the relationships between these variables. The study sought to examine these different variables, their concepts, and models and presented a proposed unified framework, as well. Not studying the relationship between these variables has left a void in research, which could jeopardize and confuse researches that study these variables. Therefore, the study provided clarity in this subject.

Since this study featured aspects of many subjects from the business world, its results can be applied to and can enhance these different subjects. This filled a research void by adding to any pre-existing research. Studying the relationship between these variables can ensure that advantages and disadvantages can be understood, so these variables can serve more efficient purposes.

The study contributed to each body of knowledge by establishing some new ideas and possibilities for upcoming research. Simultaneously, this study sought to discover and understand the relationships between different variables. It also aimed to find novel perspectives on how to view the factors under study. A practitioner could also find this study beneficial; understanding these variables and their relationship brought about more effective strategies for a practitioner to utilize. Thus, a practitioner could better understand the implications and relationship between these variables.

Additionally, this study provided a significant contribution to Industrial Engineering (IE) research, as it expedites an engineer's work process to achieve any goals more quickly. Engineers can be aided in the organization and maintenance of the system by using the latest technology, but it also helps engineers to save time, money, materials, energy, work hours, machine time, and other productivity-hindering resources. Because of this research, an engineer's productivity will improve, as this model provides innovative ideas for organizations' products and other beneficial ideas for practitioners.

This study is helpful to the research field because it provided valuable information to readers, such as industrialists. Since this study is written with simple and comprehensive vocabulary that shows how effective these variables, their concepts, and models are for companies, it is accessible to all readers. Additionally, a clear theoretical framework made additional and relevant information accessible in this study, so this can act as a reference for any future reader. It is apparent that this study acts as an important contribution to the IE profession and research field that can help companies to gain a competitive edge.

This paper was organized as follows: section two presented a high-level literature review of the current literature in these fields of research. Section three presented the research methodology utilized to execute the research study, while section four presented the findings from the study and analysis. Finally, section five outlined the implications of these findings to the practitioner, suggestions for future research, limitations of the research, and general conclusions of the research study.

LITERATURE REVIEW

Measurement System Analysis

Decisions based on measurements rely solely on how good those measurements are. The higher number of errors in the measurements means that there will be more errors in decisions. The Measurement System Analysis aimed to provide more accurate, precise, and stable data. Currently, measurement data is usually the basis for which the decision to adjust manufacturing processes (AIAG, 2010; Besner & Hobbs, 2012; Schwedes, Riedel, & Dziekan, 2017; Aslani, Akbari, & Tabasi, 2018). It is important to determine if the measurement system is qualified to reliably measure the process yield.

Characterizing a measurement system involves five ways. When a system can yield the same values over time when measuring the same sample, this is stability. The measurement of distance between the average value of measurements and the "true" value of the sample is bias. Also, a measure of regularity of bias over the range of the measurement method is linearity. To appraise whether the same evaluator can measure the same sample multiple times with the same measurement device and get the same value is called repeatability. Lastly, to appraise whether different evaluators can measure the same sample with the same measurement device and get the same value is called reproducibility.

The components segmented from observing the variation when measuring anything are shown in Figure 2.

With this analysis, the percent of variation that is caused by the measurement system is examined. Measurements between operators and between two or more measurement instruments can be compared. New instruments must have acceptable criteria before being placed in a production environment. Evaluation of suspected and repaired instruments must be taking place through analysis, as well.

The measurement system analysis evaluates whether or not a system is suitable with the task with which it is presented. The risks associated with the measurement of a process and decision-making, as well as the risk of false alarms and missed opportunities, is both reduced with Measurement System Analysis. The analysis is not only useful for auditing current measurement systems, but it also can find the most suitable system for new measurement undertakings (Dasgupta et al., 2001; Badi & Pryke, 2016; Zhang et al., 2016; Easton & Rosenzweig, 2012; Gafi & Javadian, 2018). Controlling and analyzing the stability, bias, linearity, repeatability, and reproducibility and of a system aims to assure a higher degree of measurement data goals with positive influences on the overall organizations management.

The variation from two sources; actual process variation and measurement variation is shown in Figure 3.

To evaluate the level of uncertainty within a measurement system on instruments that collect variable continuous data, Gage Repeatability and Reproducibility is used. For the Gage R&R to be performed, an instrument is selected and the following steps are needed. First, at least ten random

Figure 2. Measurement system analysis

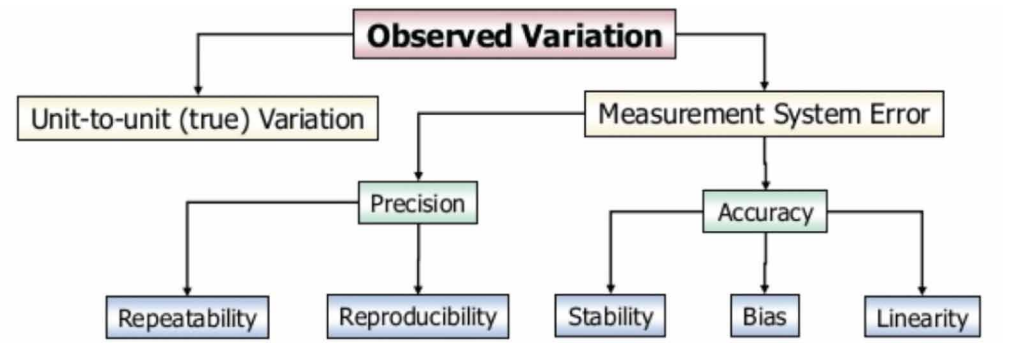
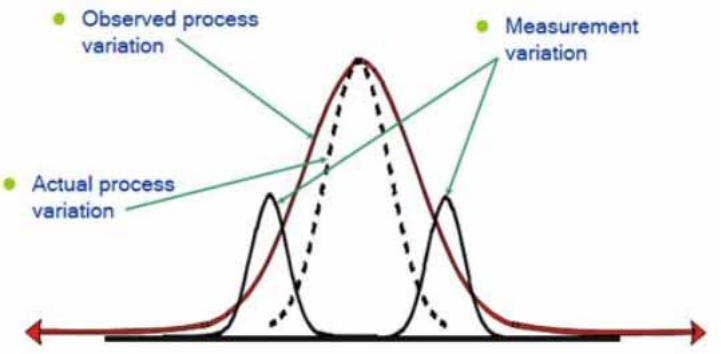


Figure 3. Observed process variation - the Gage R&R study



samples of parts manufactured throughout a normal production run must be acquired. Then, three personnel that consistently complete the specific inspection must be acquired. Every one of the personnel must measure the sample portions and document the information. The measurement procedure must be repeated three times with each personnel using the same tools. Next, the average analyses and the range of the trial averages for each of the personnel are computed. The difference of each personnel's averages, average range, and the range of measurements for each sample portion used in the report is calculated. Repeatability is also calculated to establish the amount of gage variation. Reproducibility is then calculated to determine the amount of variation introduced by the personnel. Finally, the variation in the portions and total variation percentages is calculated.

Determining if the gage is acceptable relies on these calculations, which are made with the following rules. If the Gage R&R score is below 10%, then the measurement system is acceptable. If the Gage R&R score is between 10%-20%, then the measurement system may still be deemed acceptable depending on relative importance of factors. Also, if the Gage R&R score is greater than 30%, then the system needs improvement.

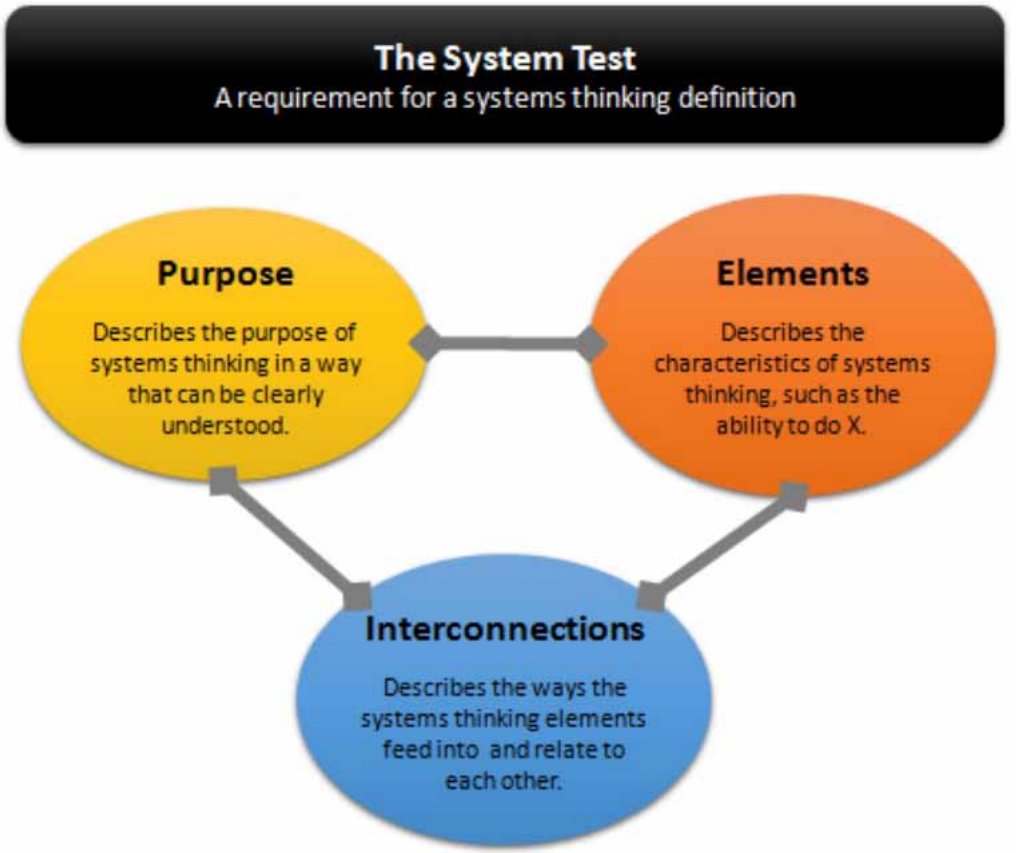
System Thinking

To analyze systems, system thinking I used. It takes a backseat from looking at isolated events and their causes, and it focuses on the whole and how every part interacts with each other (Kirkwood, 1998). The studied subject is examined for interactions between segments of the system rather individual pieces. An organization's thinking of its performance must shift. Problems are perceived to have large patterns that are interconnected once viewed from a larger perspective. Focusing on patterns of relationships and how it interacts with the rest of the parts in the system is the basis of system thinking (Aronson, 1996). To find similarities in patterns between two or more variables of interest when they are changed, behaviors in various situations are assessed. Trying to make a change in any single effort will not work because it is impossible to know everything on which to decide the isolated solution. This means that changing one element will affect the rest, so viewing the system as a whole is what is needed to successfully implement the change (Cao, Clarke, & Lehaney, 2000; Arumugam, 2016; Xiong et al., 2017; Labedz & Gray, 2013; Gholizad et al., 2017). The means to test a systems-thinking definition for systemic fidelity are shown in Figure 4.

The application of system thinking incorporates diagramming. The problem is reproduced, which provides management with the structure of the complex systems. This allows management to implement solutions that will have the best results in terms of reaching the organization's goals. The analyzation process for a problem contains five phases.

With most methods, the identification of the problem is the first step. This involves finding all entities affected by the issue and all those indirectly affected. The connection between the two must

Figure 4. The system test



then be stated (Anderson & Johnson, 1997; Galli et al., 2017; Xue, Baron, & Esteban, 2016; Elloumi et al., 2017). A feedback loop diagram must be constructed showing the relationship between all of the variables. Simulations of changes are then taken place to examine implications that may occur. Behaviors of the organization are studied to reveal consequences of the change made in the system. This is made possible with the development of a model of business issues. Scenario planning is run by the organization to allow management to view designed solutions application. Lastly, changes that are deemed successful and will share these outcomes with their constituents will be implemented by an organization (Jackson, 2003; Marcelino-Sádaba et al., 2014; Usman Tariq, 2013; Memon & Meyer, 2017). It is suggested that system thinking requires several thinking tracks simultaneously to build upon the previous thinking skill done in an order (Richmond, 1997; Parast, 2011; Von Thiele Schwarz, 2017; Hoon Kwak & Dixon, 2008).

- **Dynamic thinking:** This is essentially a mental application of the behavior. An issue can be framed in terms of a pattern of behavior over time. It means that one needs to put a current situation in the context of time scale;
- **System-as-Cause thinking:** The determination of reasonable explanations for the behavior patterns acknowledged with dynamic thinking is permitted by this thinking. Furthermore, this perspective means observing a system's behavior as the outcome of the systems and, as such, under the control of decision makers;
- **Forest thinking:** This is seeing the whole picture;

- **Operational thinking:** This tries to identify causation to determine how the behavior is produced;
- **Closed-loop thinking:** It maintains that causation does not run in just one direction, but rather an "effect" usually feeds back to influence one or more of the "causes", and that the "causes" themselves affect each other (Richmond, 1997; Todorović et al., 2015; Yun et al., 2016; Ibrahim, Abdallahamed, & Adam, 2018).

RESEARCH METHODOLOGY

Research Focus

To further comprehend how measuring System Analysis and Six Sigma relate, as well as to understand System Thinking and Six Sigma within project environments is the aim of this study. Within the project atmosphere, this research focused on examining the factors that affect the relationship. Thus, there was better knowledge of the way that project leaders could positively utilize these factors to make their projects more efficient. To highlight the relationships of these concepts, this study looked at how these concepts are applied in two different case study scenarios.

Turbo Charger Components Manufacturing Company

An organization in Romania means to implement a new instrument for measuring the diameter of the central housing for turbocharger, which is 4.0 - 4.2 mm. Additionally, performing a Gage R&R study is the aim of the organization, which will verify the consistency and accuracy of the measuring system (Simion, 2015; Svejvig & Andersen, 2015; Winter et al., 2006a; Lamaakchaoui, Azmani, & El Jarroudi, 2018).

The three selected evaluators, designated as A, B, and C, sample ten housings throughout every major source of variation. For example, the machine, time, shift, and job change are all sources of variation, and the evaluators measure every part three times and in random orders. To calculate Repeatability & Reproducibility for the analyzed caliper, this study used Minitab 16 computer software (Simion, 2015; Parker, Parsons, & Isharyanto, 2015; Zwikael & Smyrk, 2012; Sadgui & Benchekara, 2018). The general rules for gage R&R acceptability are shown in Figure 5.

The Introduction of a Systems Thinking Approach in Housing/Council Tax Benefits

The council of Blaenau Gwent County Borough served 68,400 citizens with a budget of £131,758,000, which was approximately $178,479,518.00. As of 2010, the demand for housing and council tax benefits increased significantly. The System Thinking Methodology needed to understand customer demand, which helped the team to generate one purpose for the housing/council tax benefits service as per the customer's viewpoint. Such housing benefits went to private tenants, such as private landlords and housing associations, owner-occupiers, and council tenants. For this situation, the "Check, Plan, Do" improvement cycle was selected (Zokaei et al., 2010; Brown & Eisenhardt, 1995; Sutherland, 2004; El Hissi et al., 2018). The Check model for systems thinking is outlined in Figure 6.

One must understand the demand to supply customers with what is needed. Thus, phone calls were examined, so that the team could find sufficient information about the demand, such as: the letters that were sent to customers were not understood; the customers supplied the information, while frequently being asked for more; customers frequently chased up and development on their claims; customers were given an insufficient amount of time to answer the query letters (Zokaei at el., 2010; Galli & Hernandez – Lopez, 2018; David et al., 2017; D'Emilia, Gaspari, & Galar, 2018).

As a result, the team discovered that value demand was 44%, and the failure demand was the remaining 56%, which caused the automated phone system to undergo a full review. For all of the compiled data, there were 107 questions developed and classified into nine themes. Three of those themes signified value demand. The six-failure demand is illustrated below.

Figure 5. General rules for Gage R&R acceptability

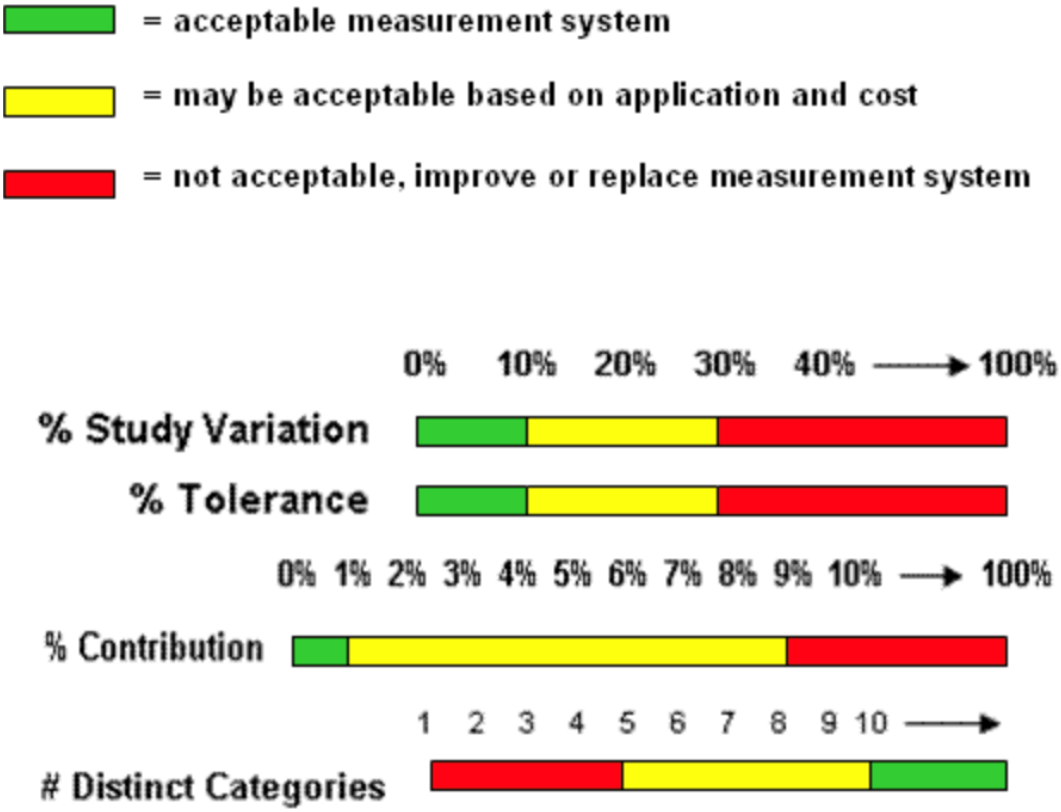
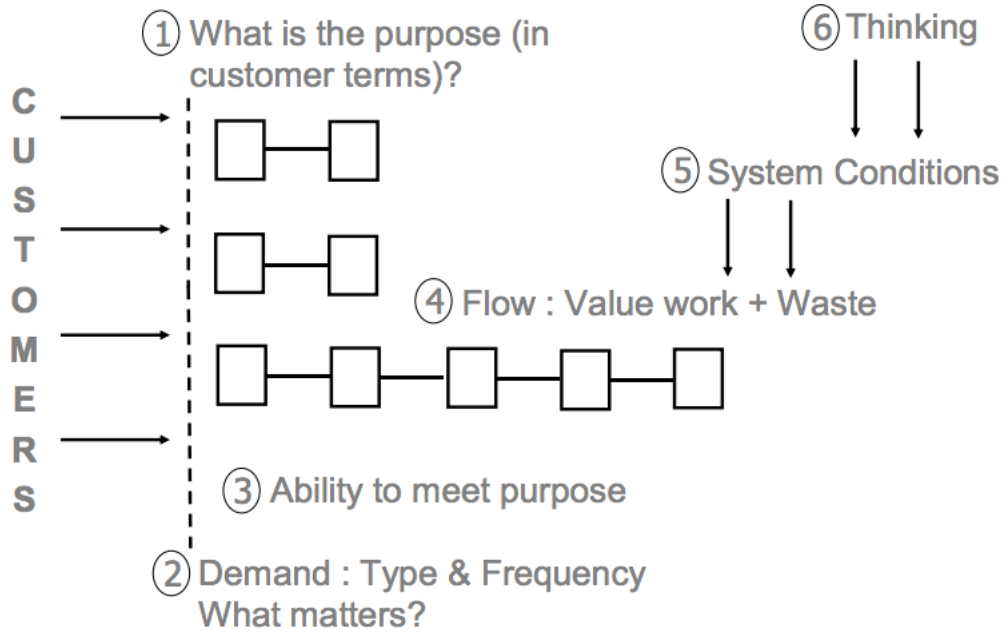


Figure 6. Check model for system thinking



Value Demand:

- How do I/Can I?
- My situation has changed
- I want to pay

Failure Demand:

- Have you received it?
- More information being supplied
- When will I receive it?
- I need information/Can you give details?
- Why are you asking?
- Not for us/ the call is for another department (Zokaei et al., 2010; Gimenez-Espin, 2013; Papke-Shields & Boyer-Wright, 2017)

Studying the 50 benefit cases led the team to discover that the "new claims" process time was 45 days, while it took 35.3 days for the "change of circumstance". Additionally, this research illustrated many problems, as seen below, which showed the need for a drastic change to the current system:

- The system lacked case ownership, so customers were juggled between people;
- Full applications needed to be completed for the simple change of circumstances;
- Customers gave superfluous information and occasionally repeated information;
- There was a mechanism in the system to synthetically halt a claim, so the claimants needed to apply again;
- Most backdating requests were declined.

Customers were requested to give information that could have been given by other sources. Most significantly, there were inaccurate end-to-end times from the customer's viewpoint (Zokaei et al., 2010; Nagel, 2015; Eskerod & Blichfeldt, 2005).

FINDINGS

Turbo Charger Components Manufacturing Company

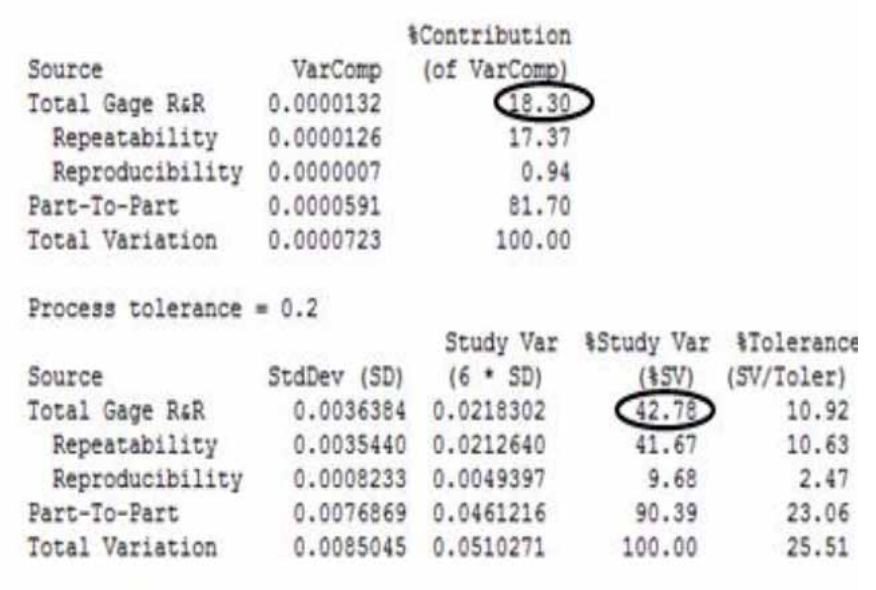
From the % Contribution, % Study Variation, % Tolerance columns, and the number of categories, this study distinguished that the acceptability criteria is not in the accepted zone. With this information, it was safely inferred that the digital caliper was not sufficient enough to measure the internal diameter. Thus, the measurement system is not acceptable. More accurate gage must be acquired to measure the parts. Once a new part is acquired, the company would need to perform a measuring system analysis to determine if that part is deemed acceptable (Simion, 2015; Xue, Baron, & Esteban, 2017; Sharon, Weck, & Dori, 2013). Figure 7 outlined the session window output for the experiment.

The Introduction of a Systems Thinking Approach in Housing/Council Tax Benefits

A group of five members were assembled to redesign and to implement a better method of working. The main objectives of this improved design were as follows: doing what matters to each claimant, verifying according to knowledge, taking each case on its merits, doing the right thing once at first point of contact, being as safe and legal as you need but no more, and attaining expertise-don't refer on (Zokaei et al., 2010; Cova & Salle, 2005; Galli and Kaviani, 2018).

A member took full ownership of a claim from beginning to end. An up-skill was needed for the members and eventually everyone involved in the cases. Customer interaction and processing of claims skill were developed through experience with the new system. Members were paired with more experienced members and taught the ropes of the new system. The new system took a few

Figure 7. Session window output for Caliper / Xbar-R method



Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0000132	18.30
Repeatability	0.0000126	17.37
Reproducibility	0.0000007	0.94
Part-To-Part	0.0000591	81.70
Total Variation	0.0000723	100.00

Process tolerance = 0.2

Source	StdDev (SD)	Study Var (6 * SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.0036384	0.0218302	42.76	10.92
Repeatability	0.0035440	0.0212640	41.67	10.63
Reproducibility	0.0008233	0.0049397	9.68	2.47
Part-To-Part	0.0076869	0.0461216	90.39	23.06
Total Variation	0.0085045	0.0510271	100.00	25.51

months to reap maximum benefits and members actively rotate from customer service, telephoning, processing claims departments, while claiming ownership of claims beginning to start. The process of new claims was reduced to 12.3 days.

DISCUSSION

As professionals in a hugely competitive world, delivering to consumers is the number one objective. To keep an organization from delivery quality service to its customers, there are many factors. The basics of operating an organization are the building blocks for everything else that come after, and the measurement system of a company is one of these building blocks. There are countless decisions, especially in manufacturing, based on measurements. As discussed in this paper, a measurement can be affected by a number of factors. Making certain that there is a capable system in place will ensure that an organization will make correct decisions based on them. An exceptional technique that is a more than adequate method to determine if a measurement system is sufficient or not is measurement system analysis. The combination of experiments and trials to determine variation accurately provide undisputable data to accept or change a measuring system.

System Thinking is likewise fundamental to an organization's success. As was discussed in the paper, it was more beneficial to address problems at its root rather than doing quick fixes. By thinking of a system as a whole and examining interactions between different parts, problems and prevention are solved on a much greater scale. Solutions that take these relationships into account achieve much better success versus those that do not. For organizations that need to address issues, System Thinking should be the ideal method for all the benefits it brings.

CONCLUSION

Turbo Charger Components Manufacturing Company

The quality of the measuring system dictates the success of the quality improvement. Also, for an acceptable measuring system and process control, measuring equipment is critical when they are working up to the standards set forth. A useful tool in measurement system analysis is Gage R&R. Reduction of measurement variation and improvement of gage repeatability and reproducibility ratios will make it easier to distinguish between parts that are in specification and those that are not. With this improvement, it is simpler when deciding to accept or reject a part (Raffaldi & Kappele, 2004; Hartono, Wijaya, & Arini, 2014; Lee et al., 2013). This is the main goal to be attained from this technique.

The Introduction of a Systems Thinking Approach in Housing/Council Tax Benefits

The previous system of Blaenau Gwen's housing and council tax benefits was centrally itemized. This central application was discovered to be the main cause of waste and poor service to its resident. System Thinking had marvelous effects both on the process as a whole and with the staff implementing it. One of the directors went so far as to say the "approach of re-designing services from the customer's perspective has proved that Systems Thinking works, with a far better service to our residents and far superior performance than that which was previously achieved. Systems thinking has enormous potential in re-shaping public sector services at a time when change is necessary due to the difficult financial climate the Country finds itself" (Zokaei, et al., 2010; Burnes, 2014; Medina & Medina, 2015).

Organizational Implications

By researching the acquired skill and management strategies, it has been found that these variables, their concepts, and models are necessary for conducting business projects and for project management. Furthermore, the variables, their concepts, and models brought about successful company and project goals by developing specific skills from a team, which is why they should be emphasized for a project or for management. The results particularly showed that strategic planning is required from leadership, along with a top-down and bottom-up approach. Such a leadership approach was most important for certain elements of project management, operations management, and process improvement. Thus, this study illustrated how critical these variables, their concepts, and models are to leadership approaches.

These variables, their concepts, and models also influenced many aspects of a business. A business' leadership and management both required certain training and skills for managing their project management and performance and the business' general growth. This study revealed that any current issues for project management and operational performance in a business are from insufficient leadership skills. The bottom line approach illustrated to yield many issues because it only focuses on profits and costs, but certain tools helped to oversee project management and operational performance to improve the business' performance.

The central finding from this study was that the variables, concepts, and models element goes ignored because finances seem to be a priority for business leaders. In the long run, a business can suffer from this approach; finances only affect the short-term. Supervising multiple elements (operations, project management, financials, performance, strategy, human resources, etc) is good long-term leadership approach. Thus, the need for all of these business elements to guarantee a successful present and future can be confirmed by leadership.

Managerial and Team Implications

There were several implications from this study. However, the primary one was that the results took a different approach in assessing the variables to fill a void research gap. The performance and

effectiveness of a business could be directly impacted by these factors, so one must study and utilize them, as well as the factors between them.

An outline for projects and performances of businesses can also be derived from this research. Through this outline, so that everyone within the business can improve on any shortcomings, there can be more productive mentoring and managerial constructs. Also, to pinpoint their causes, teams can find shortcomings within their own performances. Thus, to better meet project and departmental goals, teams can use these tools.

Lastly, the implications showed how beneficial it was to provide a more comprehensive training program that can yield project and organizations performance and effectiveness. Also, project teams, project leadership, and organizational leadership can be given training to evaluate a team, project or organization's performance alongside standard and industry accepted models and concepts. Leadership methods can also be modified by this training by educating teams and leaders on how they affect the performance and reliability of project performance and team performance and effectiveness. Overall, there will be an improvement in performance and effectiveness.

Implications and Applications to Fields of Project Management and Engineering Management

Clearly, having these variables, their concepts, and models is necessary for projects. However, the engineers and technical professions need more attention. An engineer used to be defined as someone who used technology and mathematical tools for problem solving, but an engineer is now known as someone who offers economically viable solutions with their problem solving. Thus, elements of engineering are also affected by these variables, their concepts, and models, as well. The manufacturing of a project is the basis of it, so it needs to be economically viable for profits and performance to improve. The proper choices must be made when initiating a project to avoid future errors. To guarantee that their technical knowledge can benefit investors, engineers need knowledge on business management and maturity models.

Management and engineering concepts are both scientific, which is why there are different management schools of thinking. Engineering reflects the scientific idea of "cause and effect," so management and engineering correlate. Thus, combining both concepts can be a benefit to both of them. The role of management in performance and operational-related decisions for project success was not studied enough, which is why engineering improves many of its projects through management. It was explained in research that the models that can identify the project's elements, which was traditionally described from a business perspective. As a result, this study illustrated the need to know these methods by using an engineering perspective to describe them. Also, this study addressed pure engineering filed techniques, such as budgeting, equipment, and purchasing material. This study allowed engineers and project managers to gain decision-making methods for engineering problems, as well as helped with screening projects for their viability.

This research was based on scholarly information on these variables, their concepts, and models; it deeply analyzed them and how they can affect project management and operational performance. This analysis was meant to pinpoint the proper practices for these variables, their concepts, and models for future reference. Also, it provided valuable information about project management and operational performance, as well as managing these elements. This study's research also focused on helpful literature for managing projects and improving the pre-existing management standards.

Project management and operational performance is needed by the IE/EM profession and research field. Since these variables, their concepts, and models feature the best concepts for projects, all problems may not be resolved with lean thinking. However, the structural orientation of a scope can make the IE/EM players generate the necessary scopes of interest at any level. To generate the performance that can lead to the same results, a more tactical approach is needed.

Furthermore, this study contributed to industrial engineering and engineering management, as all business fields need project management for new products and services to succeed. This study also

featured information for stakeholders about applying maturity to project management. Furthermore, stakeholders, such as system engineers or project managers, will be inspired to best utilize the system engineering and project management roles to ensure that business projects will succeed.

Literature did not contain enough information about these variables, their concepts, and models, even though they are used by businesses. Thus, studying how project management and operational performance development were affected covered some new territory. Using systems thinking with new product development goals was useful, as it can make products more profitable. This study paved the way for more research on how small companies, without many established processes, can make new products, as the product under consideration was the company's second product.

Limitations

There were some limitations to the study and results; mainly, the study had a limited sample size that only studied key factors. Some bias and validity for the findings and conclusions could have arisen, so there could have been a larger sample size to avoid this. Additionally, this study only assessed the key factors and their relationship within a project environment. Thus, the conclusions and analysis were exclusive to project environments. The findings could not really be applied to other arenas (supply chain management, operations management, strategic management, etc.). As a result, one could not really argue that the findings are applicable to other industries or managerial settings.

Future Research

A few areas that should be explored in future research, such as how these factors and their relationship work in other industries and managerial settings. The strengths and weaknesses of these variables and the relationship in these settings could be assessed, as well as how the settings influence these factors and their relationship. Additionally, these factors from an organizational, strategic, or cultural perspective could be explored to show how the relationship is seen in many different views. Thus, how culture, strategy, human resources, and operations affect the key variables and their relationship can be further understood.

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