13th International Scientific Conference

BUSINESS AND MANAGEMENT 2023

May 11–12, 2023, Vilnius, Lithuania

ISSN 2029-4441 / eISSN 2029-929X
ISBN 978-609-476-333-5 / eISBN 978-609-476-334-2
Article Number: bm.2023.1036
https://doi.org/10.3846/bm.2023.1036

BUSINESS TECHNOLOGIES AND SUSTAINABLE ENTREPRENEURSHIP *http://vilniustech.lt/bm*

HOW TO DEVELOP AN EFFECTIVE PRODUCT TRAINING? DESIGN FOR SIX SIGMA APPLICATION CASE

Marcin NAKIELSKI[1, 2], Grzegorz GINDA [3*]

[1]*PhD School, AGH University of Science and Technology, ul. Mickiewicza 30, 30-059 Cracow, Poland*
[2]*Nexteer Automotive Poland Sp. z o.o., ul. Towarowa 6, 43-100 Tychy, Poland*
[3]*Faculty of Management, AGH University of Science and Technology, ul. Gramatyka 10, 30-067 Cracow, Poland*

Received 3 March 2023; accepted 4 April 2023

Abstract. Design for Six Sigma – DFSS – approach through the years has proven to be effective in development of products and processes. Method has originated in industry being successful in automotive, aviation, machine construction and other sectors. However, the paper describes usage of design for Six Sigma methods and tools in a unique field – to develop successful and effective product training. IDDOV approach, applied with this regard, helps, among others, to understand and classify customer requirements, select proper design, verify the results from pilot testing and recommend process owner optimized service. Presented material provides evidence that Design for Six Sigma is an effective tool also in the case of training development. Moreover, the universality of DFSS methodology makes it relevant for any application area with this regard. Described approach, proving universal usage of DFSS methods and tools, is relevant for any development team in the field of training design.

Keywords: product, development, training, support, Design for Six Sigma.

JEL Classification: M53.

Introduction

Design for Six Sigma (DFSS) is a methodology that can be used to systematically design new products, services, or processes. DFSS focuses on designing a product, service, or process right the first time so less time needs to be spent downstream in improving the product, service, or process (Cudney & Furterer, 2012). Methodology is based on the project approach which strictly defines phases and tasks that allow design team to be efficient and errorless in the process of product or services development.

As the methodology, started in 1980's in the US, proven to be effective in the industry (automotive, aviation, electronics, etc.), other sectors begun using this approach. Nowadays it is easy to find numerous publications and examples of the successful introduction in the field of medical care, financial business, insurance companies, schools, government institutions, and others.

Characteristic for Six Sigma is the structural approach (Bloom, 2022) that consist phases of Define, Measure, Analyze, Improve, Control (optimization projects) or Define, Measure, Analyze, Develop, Verify (Design for Six Sigma projects). Numerous, ready to use, specific tools are available for project teams to support of the realization of each of those phases and to drive successful project completion. Those tools can be utilized as part of the project, but also have universal applications beyond Six Sigma.

Since Six Sigma, and especially Design for Six Sigma, offers structural process approach to develop products and services, a Product Development Team in the considered case decided to use this approach while designing product training. However, there isn't any sign in existing publications of the application of a set of tools and structural process that Design for Six Sigma offers to take a similar challenge. This is also why some exemplary tools that were used with this regard in the considered case are described in the paper.

General scope of the development team was to design product training offered by the team to other functions within organization. Chosen IDDOV approach, through the usage of multiple tools, addresses the requirements of the customer – training participants, trainers, and

* Corresponding author. E-mail: *gginda@agh.edu.pl*

organizers. A post training survey was applied as an immediate measure of customer satisfaction and effectiveness of the training.

The paper presents effects of the work of product team, and thus proofs usage of DFSS tools in the field of product training design. With presented path of the project team efforts, followed by the summary and rating of the service provided by the customer, reader will be able to understand the effectiveness of DFSS process in any field, not only engineering-design related one.

Overall – presented material and completed activities are utilized to address identified research question: are Design for Six Sigma approach and tools effective in case of training development?

The paper is structured as follows. Section 1 presents literature survey on Design for Six Sigma, with general overview of applications, tools, and methods. Basic phases of training development are also described there based on available literature. Section 2 describes particular techniques used to address the problem, with phase-by-phase IDDOV (Jensen et al., 2008) approach and explanation of individual tools applied in the course of the project. Lastly, Section 3 brings conclusions drawn from the above activities.

1. Materials and methods

1.1. Literature survey on Six Sigma and Design for Six Sigma

High level Six Sigma definitions typically have organizational and business focus (Eckes, 2001a, 2001b). Harry and Schroeder define Six Sigma as a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction (Harry & Schroeder, 2000). Yang and El-Haik bring the following definition: Six Sigma is a methodology that provides businesses with the tools to improve the capability of their business processes. (…) In Six Sigma, the purpose of process improvement is to increase performance and decrease performance variation. This increase in performance and decrease in performance variation will lead to defect reduction and improvement in profits, to employee morale, and quality of product, and eventually to business excellence (Yang & El-Haik, 2009). Other definitions of emphasize data driven aspects and toolsets: Six Sigma is a disciplined method of using extremely rigorous data-gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them (Harry & Schroeder, 2000).

The definitions presented above are referring to the business and organization aspects of Six Sigma, however frequently Six Sigma is associated or understood as the DMAIC model (Pande et al., 2000). DMAIC is the problem-solving method based on phase-by-phase structured approach with following steps and tasks (Echeveste et al., 2016):

1. Define – is to identify the CTQs (characteristics critical to quality) and the process to be improved.
2. Measure – identify the potential sources of variation of the process and its current capacity.
3. Analyze – identify the sources of variation that significantly affect the process.
4. Improve – identify actions to increase the capacity.
5. Control – take actions that help control the sources of variation to maintain the capacity of the process.

As the methodology was developed based on organizational needs for variation reduction and process optimization, it was very rapidly discovered, that up-front proper design, will lead to the most efficient processes and successful business outcomes. With that goal – to assure error free designs at the early stage of life of product and processes – Design for Six Sigma was developed. Yang and El-Haik refer to the definition: Design for Six Sigma (DFSS) is the Six Sigma strategy working on early stages of the process life cycle. (…) It will start at the very beginning of the process life cycle and utilize the most powerful tools and methods known today for developing optimized designs. These tools and methods are ready to plug directly into current product development process, or design/redesign of a service process or internal business process (Yang & El-Haik, 2009). Other definition, brought by Hahn and Doganaksoy, focuses on objectives of the methodology: The objective of DFSS is to design products, services and processes that are Six Sigma capable. A major goal is to minimize the occurrence of unpleasant last-minute surprises and hick-ups that are traditionally associated with introduction of new products, services, and processes (Hahn et al., 2000).

Similar to DMAIC approach, DFSS brings disciplined phase-by-phase method (DMADV) focused on following steps (Figure 1):

1. Define – to identify new product, process, or service to be design and clarify project boundaries.
2. Measure – to understand customer needs and requirements, and then translate them into measurable design parameters.

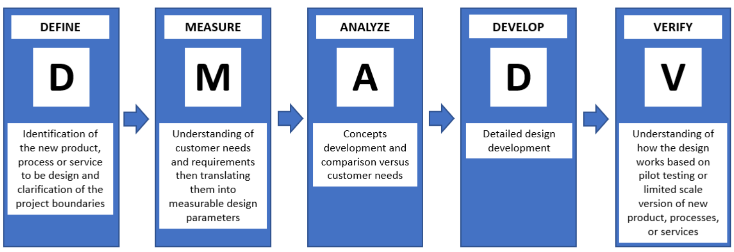

Figure 1. Disciplined phase-by-phase DFSS approach (source: own work)

3. Analyze – to develop concepts and compare them versus customer needs.
4. Develop – to develop detailed design.
5. Verify – to understand how the design works based on pilot testing or limited scale version of new product, processes, or services.

As the model above is general to DFSS, there are several approaches that can vary based on the application of the procedure. Other known models are (Francisco et al., 2020):

– IDDOV; Identify and Initiate, Define Requirements, Develop Design, Optimize Design and Verify and Control.
– CDDOV; Concept, Define, Design, Optimization and Verification phases.
– CDOV; Concept, Design, Optimize, Verify.

Nowadays Six Sigma and Design for Six Sigma techniques are widely used in many industries, demonstrating potential of project approach for effective problem solving, process optimization, variation reduction and structured process design. Six Sigma originated from manufacturing area, and it is still being frequently used there, however the list of areas where DMAIC or DMADV projects are used is longer, including: engineering and construction, finance, supply chain, healthcare and others.

1.2. Literature survey on training development

Training development or design methods and phases are widely described in the literature. Anandaraja and Sontakki suggest the following: in whatever way we understand training, either a continuous or dynamic process, it involves four major stages namely planning, preparation, conducting and evaluating (Figure 2). These stages in turn may be construed in the form of definite steps for effective design and management of training (Anandaraja & Sontakki, 2015).

Planning is a first stage of training development. Phase starts with communication with the customer to define training goals with the aspects of business needs as well as goals in aspects of participants and their expectations towards training process. It is important to define list of competencies that should be developed during the training. Also, at this stage goals and objectives shall be identified. While analysing customer needs it is critical to identify of all conditions affecting effectiveness of training, including cultural, organizational, relationship and environmental aspects of training participants (Kwapisz et al., 2008).

Second stage of the training development is preparation. At this point, design team shall organize the training content addressing training objectives. Team should select proper training methods and techniques – to provide trainee learning activities that effectively present the content and help them accomplish training objectives (Anandaraja & Sontakki, 2015). The identification of required training resources, such as facility, equipment, and materials is also part of this stage. Lastly, with lesson plans diligently created, the team should focus on development of materials, such as audio-visual teaching aids, trainers reference materials, trainee handouts and learning aids.

Implementation/Conducting the training step is related with the first and the following training sessions. Frequently it would start with try-out sessions, conducted with smaller groups of people, followed by training program evaluations. Such activity might lead to training program revisions and improvements. Ultimately, this stage of training development ends with training sessions provided to targeted audience.

Finally, evaluation of the training session phase completes the training development process. The phase starts with the development of the tests and methods for measuring the trainee learnings. It targets both the effectiveness of the training with regard to customer objectives and needs and well as the evaluation of the participants' feedback on the program.

It is important to mention, that the considered Six Sigma development team did not intent to diminish the value of methods and processes described above. DFSS tools and techniques in this case work hand in hand with known training development process, providing complementary view on the needs, design, implementation, and evaluation of the training sessions.

Literature survey presented above, as well as other reviewed materials and publications, undoubtedly confirm reasonableness of research question authors decided to address in the paper.

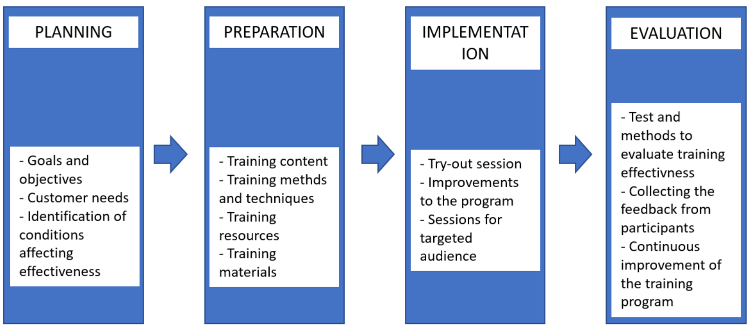

Figure 2. Training development stages (source: own work)

2. Results and findings

The paper is meant to describe the path of Design for Six Sigma team to develop product training. The approach taken by the team is in line with the DFSS recommended, project based, disciplined structure well known from engineering and manufacturing fields. The uniqueness of the study is related to the connection of the design method used with designed service, such as product training. As engineering team is familiar with the Design for Six Sigma tools and methods, it was for the first time when these methods were used to design a training. What is more – used approach, in a conclusion was proven to be effective in providing well-received service, satisfying all involved customers.

Engineering Team was challenged to design and provide advanced product training in the field of mechanical design of Electric Power Steering (EPS). Team involved in that task consisted of mechanical product engineers, who were specialized in areas of individual components used for EPS (i.e., castings, gears, polymers, etc.). They also had good understanding of how those components work in the assembly, what are their functions, what are the failure modes, etc. As the main customers of the service team have identified other members of the organization, holding engineering positions, from manufacturing, quality, and product engineering groups.

Project team has approached the problem of development of product training session using Design for Six Sigma tools (Allen, 2019). IDDOV scheme was applied to express basic structure of the project model that was capable of ensuring the completion of the following project steps:

1. Identify & Initiate – outcome of this phase of the project was to define project goal, project timeline and identify necessary resources.
2. Define Requirements – this phase was concentrated on identification of customers, their requirements, assigning priority for those requirements, translating them into measurable characteristics.
3. Develop Design – as an outcome of this phase team needed to identify design for further optimization. Frequently several design options were analysed and compared at this step.
4. Optimize Design – this stage made use of tools and methods that helped the team to identify key design characteristics and optimize the design.
5. Verify & Control – outcome of this phase dealt with the verification of project assumptions, with design testing and the definition of control tools for the implementation teams.

Team has started with creating project charter (Figure 3), where scope of the project was identified. The same document contains information about team members, deliverables of the project that team commits to deliver and importance of the project to the organization. In addition, team has decided on main project plan – including resources and timelines. Those steps completed Identify and Initiate stage of DFSS project.

Following was a team brainstorm session (Osborn, 1948) where customer was identified as well as initial approach to collecting customer requirements. Deeper dive into that topic was approached with next tool: Requirement Analysis. Team investigated two groups of customers: training participants and trainers that were assigned to lead the classroom sessions. From both groups Voice of Consumer – VOC (Dale & Tidd, 1991) was gathered and analysed.

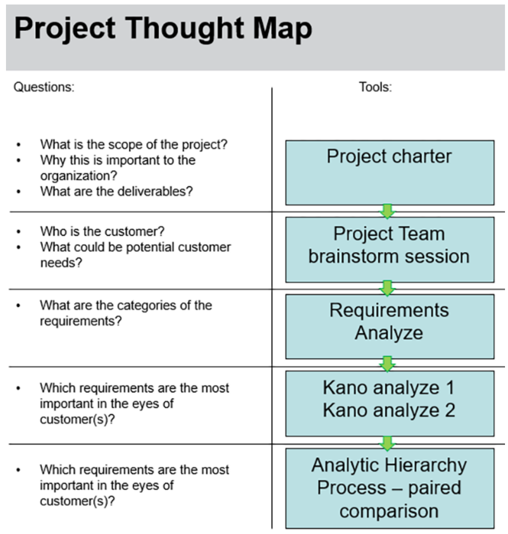

Figure 3. Thought map – tools used in first phases of the project (source: own work)

Team has recognized the need of assigning priority to identified requirements and for that Kano analysis (Shahin & Zairi, 2009) was used. The Kano model defines three types of quality requirements:

- One-dimensional quality – is a specifically requested item. If present, the customer is satisfied. If this characteristic is absent, the customer is dissatisfied.
- Expected or basic quality – these elements or customer requirements are not specifically requested, but they are assumed by the customer to be present. If they are present the customer is neither satisfied nor dissatisfied. If they are absent, the customer would be very dissatisfied.
- Exciting or delightful quality – this level of quality characteristics is unknown to the customer. It is not something that they would think to ask for. These elements are the most difficult to define and develop. If present, the customer is very satisfied. If absent, the customer is neither satisfied nor dissatisfied.

The Kano model also defines how the achievement of these requirements affects customer satisfaction (Cudney & Furterer, 2012).

Further analyses of the requirements were completed using a specific Multi-Criteria Decision Analysis (Ishizaka & Nemery, 2013) methodology implementation tool, namely: Analytic Hierarchy Process – AHP (Saaty, 1980), where customer needs were ranked, identifying most important aspects for each group of customers.

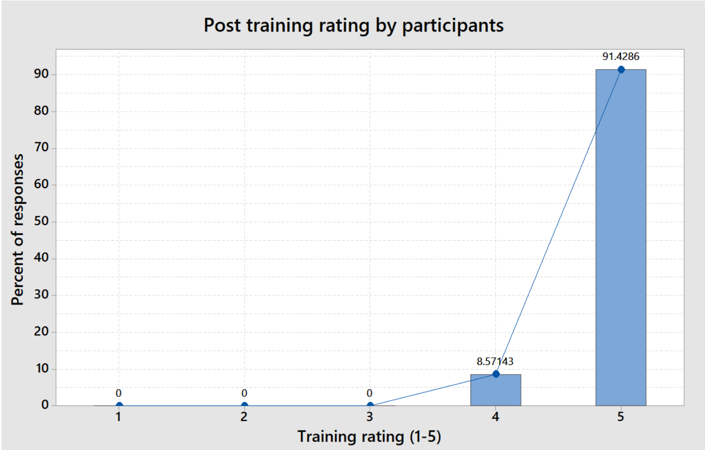

Figure 4. Post training participant survey results (source: own work)

With the requirements identified team proceeded with advanced tool – Quality Function Deployment: House of Quality (Kogure & Akao, 1983). Quality function deployment and the House of Quality is an excellent tool to help to translate customer requirements from VOC into the technical requirements of your product, process, or service (Cudney & Furterer, 2012). Using the tool team has prioritized most important design parameters, keeping knowledge of what to focus on in the design step.

Above tools and steps completed Define Requirements phase of DFSS project.

In the next steps team was focused on the definition of design proposals (Figure 5). Five concepts were created – taking into consideration variation of design parameters, such like training duration, location, training program, training techniques, etc. For the selection of the best solution, taking into consideration previously defined requirements team used Pugh concept selection tool (Hock, 1997). Pugh proposed a matrix evaluation technique that subjectively weighs each concept against the important technical criteria and customer concerns from a total perspective (Yang & El-Haik, 2009). Those tools complete Design stage of DFSS project.

Optimize stage of the project started with planning of the pilot testing – first training session, limited to smaller group of participants. Prior to that, team of trainers went through special Train the Trainer sessions, allowing them to increase the awareness in teaching methods and gain trainer's competencies. Following first sessions – participants were surveyed and asked to provide the feedback about training program. Necessary changes were implemented to the design based on that.

With all above steps completed team was ready to implement final design (Figure 6). Training sessions were planned and conducted. As a control tool design team prepared training evaluation sheets as well as final test to understand effectiveness of the training methods. Training evaluation survey presented satisfying results (Figure 4). Participants were surveyed for overall training score on the scale from 1 to 5, where 5 means the best training rating. The average score of 4.91 of participants' ratings is obtained and over 91% participants indicated the highest score level. All results presented above were collected among the training participants who attended the training sessions in 2022.

Finally proper documentation was created and shared to assure repeatability of previously defined training process. Above steps completed Verification & Control phase of the project.

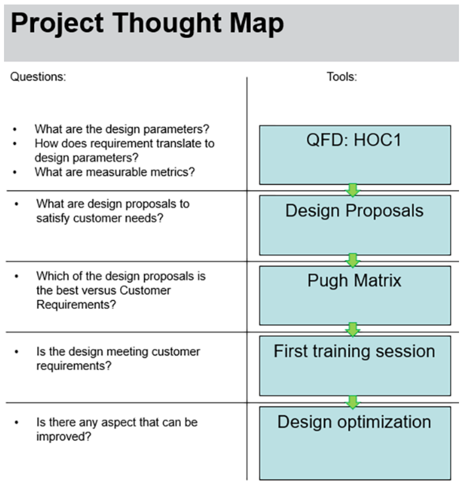

Figure 5. Thought map – tools used in further phases of the project (source: own work)

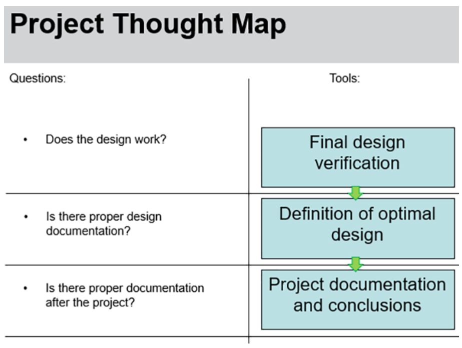

Figure 6. Thought map – other tools used in further phases of the project (source: own work)

3. Discussion

Considering described above path of the project team towards successful implementation of the training designed with IDDOV methods, conclusion can be drawn that Design for Six Sigma is a proper approach supporting preparation of the service, such as product training. It seems that this the versatility of applied tools, such as Requirement analysis, Kano analysis, Pugh Matrix, Quality Function Deployment, and others, that leads to robust design of training related service.

Result of the post training survey suggest that the training was well received by the customer, in this case training participants. Collected data are referring to post training impressions of the attendees, which is an immediate measure of the service quality.

Immediate results of the case study show that IDDOV method application for complex product training development with the purpose of knowledge share and competency growth in the organization brings multiple benefits. Detailed approach, starting with focus on understanding of customer requirements, requirements prioritization, analysis of different design solutions, and finally the implementation and proper process documentation is capable of addressing the needs of the organization and leads to robust, high-quality service. However, it is also important to mention that such approach is complex and time consuming for a design team. It is not recommended, therefore, for simple service designs, where detailed analysis is not going to lead to tangible benefits.

Conclusions and limitations

Available literature shows diverse training design tools that are aimed at achieving the effectiveness and customer satisfaction. The presented case study shows successful path of the project team to develop product training by means of DFSS methodology application which has not been applied for such purpose at all, yet. Specific application of the methodology – IDDOV approach, namely, led project team from customer requirements, through design selection, pilot testing, service implementation and project documentation. As a post training survey revealed, the application of the approach finally resulted in achieving customer satisfaction. The immediate outcome of the case study seems to provide positive answer to the research question about usability of DFSS for training and product training in particular, therefore. The methodology turns out to be a competitive alternative to common tools for training design, therefore. The outcome of presented case study seem to provide positive answer to the research question about usability of DFSS methodology for product training design, and hopefully – for a general training design.

All in all, a unique application of the methodology, makes any in-depth research welcome as it could also reveal both merits and possible limitations of the methodology. There are nevertheless several open questions which seem particularly interesting to be answered in the future to comprehensively assess DFSS usability for training design support. For example, the analysis of long-time effects of its application would help in this regard. This is because training may provide participants with knowledge and skills which may only gradually reveal in an everyday practice of training participants and influence actual effects of their activities. Another example of possible future research deals with the assessment DFSS application for training design in diverse areas.

Funding

The APC was funded under subvention funds for the Faculty of Management of the AGH University of Science and Technology, Cracow, Poland.

Author contributions

Conception and design of the work (M. N., G. G.), acquisition of data (M. N.), or analysis and interpretation of data (M. N., G. G.), drafting and editing the article (M. N., G. G.), revising the article critically for important intellectual content (M. N., G. G.).

Disclosure statement

The authors declare that they have any competing financial, professional, or personal interests from other parties.

References

Allen, T. (2019). *Introduction to engineering statistics and Lean Six Sigma: Statistical quality control and design of experiments and systems*. Springer. https://doi.org/10.1007/978-1-4471-7420-2

Anandaraja, N., & Sontakki, B. S. (Eds.). (2015). *Conducting an effective and successful training programme*. NIPA, New Delhi, India.

Bloom, D. T. (2022). *Achieving HR Excellence through Six Sigma*. Routlege. https://doi.org/10.4324/9780429433832

Cudney, E. A., & Furterer, S. L. (2012). *Design for Six Sigma in product and service development*. CRC Press.

Dale, B. G., & Tidd, J. (1991). Japanese total quality control: A study of best practice. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *205*(4), 221–232. https://doi.org/10.1243/PIME_PROC_1991_205_074_02

Echeveste, M. E., Rozenfeld, H., & Sonego, M. (2016). Potential application of Six Sigma tool in the integrated product development process. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, *38*(8), 2499–2511. https://doi.org/10.1007/s40430-016-0503-0

Eckes, G. (2001a). *Making Six Sigma last: Managing the balance cultural and technical change*. Wiley.

Eckes, G. (2001b). *The Six Sigma revolution: How general electric and others turned process into profits*. Wiley.

Francisco, M. G., Canciglieri, J. O., & Sant'Anna, Â. M. O. (2020). Design for six sigma integrated product development reference model through systematic review. *Interna-*

tional Journal of Lean Six Sigma, *11*(4), 767–795. https://doi.org/10.1108/IJLSS-05-2019-0052

Hahn, G. J., Doganaksoy, N., & Hoerl, R. (2000). The evolution of Six Sigma. *Quality Engineering*, *12*(3), 317–326. https://doi.org/10.1080/08982110008962595

Harry, M., & Schroeder, R. (2000). *Six Sigma: The breakthrough management strategy revolutionizing the world's top corporations*. Doubleday, New York NJ.

Hock, T. E. (1997). Integrated product development. *Sadhana*, *22*, 189–198. https://doi.org/10.1007/BF02744488

Ishizaka, A., & Nemery, Ph. (2013). *Multi-criteria decision analysis: Methods and Software*. Wiley. https://doi.org/10.1002/9781118644898

Jensen, C., Quinlan, J., & Feiler, B. (2008). *Robust engineering and DFSS: How to maximize user delight and function and minimize cost* (SAE Technical Papers 2008-01-0361). https://doi.org/10.4271/2008-01-0361

Kogure, M., & Akao, Y. (1983). Quality function deployment and CWQC in Japan. *Quality Progress*, *16*(10), 25–29.

Kwapisz, J., Godzisz, M., Iwińska, K., Kolenda, J., & Kopijer, P. (2008). *A trainer's handbook prepared as part of the Good NGO Trainer Project* [Podręcznik trenera przygotowany w ramach projektu Dobry Trener NGO]. Stowarzyszenie ASTD Global Network Poland, Warszawa, Poland.

Osborn, Ch. (1948). *Your creative power: How to use imagination*. Charles Scribner's Sons.

Pande, P. S., Neuman, R. P., & Cavanagh, R. R. (2000). *The Six Sigma way: How GE, Motorola, and other top companies are honing their performance*. McGraw-Hill Professional.

Saaty, T. L. (1980). *The analytic hierarchy process: Planing, priority setting, resource allocation*. McGraw-Hill.

Shahin, A., & Zairi, M. (2009). Kano model: A dynamic approach for classifying and prioritising requirements of airline travellers with three case studies on international airlines. *Total Quality Management and Business Excellence*, *20*(9), 1003–1028. https://doi.org/10.1080/14783360903181867

Yang, K., & El-Haik, B. S. (2009). *Design for Six Sigma: A roadmap for product development.* McGraw-Hill.