SQC EDUCATION PROVIDED BY THE UNION OF JAPANESE SCIENTISTS AND ENGINEERS: PRACTICAL STATISTICAL EDUCATION FOR ENGINEERS IN INDUSTRY

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The Union of Japanese Scientists and Engineers (JUSE) has made a significant contribution to Japanese industry through its research and dissemination of Total Quality Management (TQM) and other scientific management techniques. In particular, featuring curricula that blend statistical theories with practical quality control, its statistical quality control (SQC) education programs have for many years produced talented quality control experts for industry. These programs have thus played a key role in cultivating personnel to support Japanese quality, which is pre-eminent in the world. Today, JUSE provides education in statistical techniques not only for personnel working in manufacturing industry, but also for those working in the realms of pharmaceuticals and medical care, and in the software field.In this session, I will provide an overview of the typical curricula for JUSE´s SQC education programs, as well as introducing examples of the use of statistical techniques in manufacturing industry.

STATISTICAL QUALITY CONTROL IN JAPAN: HISTORY AND EDUCATION PROGRAMS FOR INDUSTRY

After World War II, Japan's industrial products were of inferior quality. The label "MIOJ: Made in Occupied Japan" was synonymous with shoddy goods that were derided as cheap and nasty, so improving product quality was a challenge for Japanese companies at that time.

In 1949, JUSE held the 1st QC Basic Course (which in those days was called the Statistical Quality Control Seminar). The following year, JUSE invited the American statistician Dr. W. Edwards Deming to give lectures on such topics as the use of statistics in quality control, control charts, and sampling tests. This seminar was the catalyst for the founding of the Deming Prize1) in Japan. In 1951, JUSE launched the world's first education program focused on the PDCA cycle.

Also, the research conducted around that time by Dr. Genichi Taguchi into design of experiments (improving orthogonal arrays and devising linear graphs) and the guidance that he provided to various companies contributed significantly to the widespread adoption of design of experiments by industry. The tile firing experiment conducted in 1953 by Ina Seito Co., Ltd. (known today as LIXIL) is particularly famous. Based on his wealth of experience in advising companies, Dr. Taguchi also created the unique technique called robust design (parameter design).

In 1954, JUSE invited American quality control expert Dr. Joseph M. Juran to give a seminar for business leaders and executives. Until then, SQC had been limited to manufacturing and inspections, but at this seminar, Dr. Juran expanded the concept's scope, positioning it as a management tool. This had a tremendous impact on Japanese industry.

In 1962, the magazine Genba To QC (Quality Control for the Foreman) was founded under Dr. Kaoru Ishikawa, the Father of the QC Circle, and many companies introduced QC Circles as a form of small-group kaizen activity. SQC also began to take root, primarily on the shop floors of manufacturing companies, and these two elements working in tandem brought about a dramatic improvement in the quality of Japanese products.

Remarkable advances in computer technology in the first half of the 1970s made it possible to process large quantities of data easily. Responding to the increasing accessibility of multivariate analysis techniques to a larger number of people, JUSE held the 1st Multivariate Analysis Seminar in 1970. The following year, the Society for Multivariate Analysis was established to facilitate research by industry and academia, and to expand the techniques' fields of application (today, only seminars are held).

In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10, July, 2018), Kyoto, Japan.* Voorburg, The Netherlands: International Statistical Institute. iase-web.org

In the latter half of the 1970s, Dr. Taguchi embarked on research into the Mahalanobis distance, which was propounded by Dr. Prasanta Chandra Mahalanobis of the Indian Statistical Institute. Dr. Taguchi continued to develop this research, and the pattern recognition and forecasting technique called the Mahalanobis-Taguchi (MT) system is now rapidly being adopted by industry.

Big data began to become the focus of attention in both Japan and the U.S. in the latter half of 2011, with some people noting that there was a pressing need to train data scientists, who are experts in big data analysis. In response, JUSE held the 1st Data Science for Problem-solving in Manufacturing Introductory Course in 2015.

Thus, JUSE has achieved improvements in quality and productivity, changing to meet the needs of the times, while consistently delivering SQC education that enables engineers to put a variety of statistical techniques to use on the front lines of industry. (See Figure 1. Main SQC Programs Organized by JUSE)

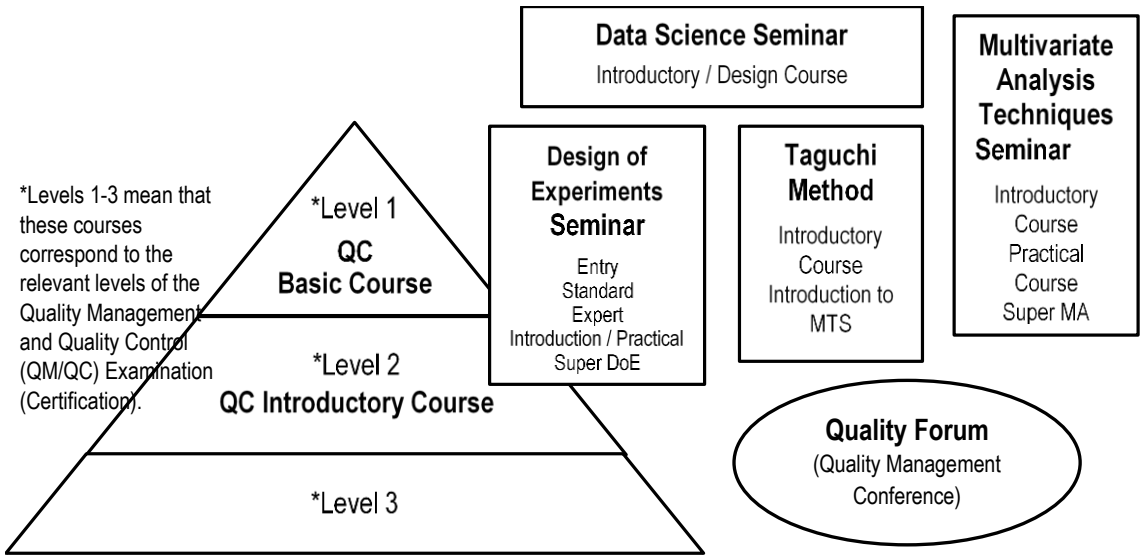

Figure 1. Main SQC Programs Organized by JUSE

OVERVIEW OF SQC SEMINARS ORGANIZED BY JUSE

Quality Control Seminar Introductory Course

[*Overview*] Through this course, staff from all corporate departments, including quality control and technical departments, can learn the fundamentals of statistical quality control within a short period. It is a sister course to the Quality Control Seminar Basic Course and corresponds to Level 2 of the Quality Management and Quality Control (QM/QC) Examination (Certification).

[*Target Participants*] Those who wish to master statistical quality control concepts and basic techniques within a short period

[*Duration*] 8 days (Part 1: 4 days. Part 2: 4 days)

[*Subjects*] Includes: Introduction to Quality Control; Organizing Data; Basic Statistical Methods; Seven QC Tools; Testing and Estimation; Control Charts; Design of Experiments and Variance Analysis; Correlation and Regression; Inspections; Process Improvement and Control; Approaches to Total Quality Control; Mock QM/QC Examination with Explanation of Answers

Quality Control Seminar Basic Course

[*Overview*] This course is designed to cultivate experts in Total Quality Management, which is one of Japan's greatest traditions and achievements.

It features lectures covering all aspects of the key technologies of quality control, along with tests to gauge participants' level of understanding and guidance to assist in tackling individual themes for improvement. Over the last 68 years, it has been held 131 times, incorporating a total of 302 classes, and has produced 34,103 trainees for industry.

It corresponds to Level 1 of the Quality Management and Quality Control (QM/QC) Examination (Certification).

[*Target Participants*] Engineers and other staff who have at least 3 years of practical experience

[*Duration*] 30 days (5 days/month × 6 months)

[*Subjects*] Includes: TQM for Engineers and Staff; Collecting and Organizing Data; Problem Solving Methods; Basic Statistical Methods; Testing and Estimation; Control Charts; Variance Analysis; Design of Experiments; Process Design and Management; New Seven QC Tools; Customer Needs Analysis and Management; Regression Analysis; Sampling Tests; Attributes Data Analysis; Sampling; Dispersion Estimation and Management; Quality Control in Design and Development; Non-parametric Methods; Reliability Engineering; Trouble Prediction and Prevention; Management of Purchasing and Outsourcing; Taguchi Methods; Sensory Evaluation and Perceived Quality; Building Quality Assurance Systems; Building and Operating Business Management Systems; Multivariate Analysis Techniques

Three particularly noteworthy elements of the curriculum are the following:

- *Study groups*: Participants come prepared with details of the themes for improvement that they are addressing in their own workplaces and receive support in resolving them through one-on-one counseling sessions and group discussions with other participants and course lecturers. These groups have won tremendous acclaim, as they provide opportunities for interaction with people in other industries, in addition to offering training in putting statistical techniques into practice.
- *Homework exercises*: Each month, participants are set a homework exercise based on practical quality problems. Participants who provide exemplary answers give a presentation about their response, which is followed by a discussion between the lecturer and the course participants. One could describe this element of the curriculum as being similar to the flipped classroom.
- *Case studies:* Through group discussions, participants learn about ways of using and applying problem-solving techniques, process analysis, quality function deployment (QFD), regression analysis, and design of experiments in practice, thereby ensuring that they can be immediately effective in the workplace.

The education method now called active learning is being used from an early stage on this course and we have received a great deal of positive feedback about this from industry, to the effect that this aspect of the curriculum helps to cultivate practical skills.

Design of Experiments Seminar

The Design of Experiments Seminar was established in 1950 for those who had completed the QC Basic Course. Three courses are offered, tailored to the content that participants wish to learn: Entry, Standard, and Expert. (The following outlines the content of the Expert Course)

[*Overview*] Participants can acquire technology development skills through introductions to cutting-edge techniques and multiple examples of their application, along with exercises using statistical analysis software (JUSE-StatWorks).

[*Target Participants*] Staff from technical, design, and new product development departments who have a basic knowledge of the subject (equivalent to having completed the Standard Course)

[*Duration*] 6 days (2 days/month × 3 months)

[*Subjects*] Includes: Role of Statistical Techniques in Technology Development; Variance Analysis; Orthogonal Arrays; Parameter Design; Method of Least Squares; Response Surface Methodology; Optimal Design; Multi-Objective Design Exploration; Simulation Experiments; Robust Optimization

One particularly noteworthy point about this course is that the lecture about cutting-edge techniques is followed by an introduction to examples of the use of those techniques on Toyota Group factory floors. In addition, participants undertake exercises that let them try out the same analyses introduced in the examples.

Multivariate Analysis Techniques Seminar

Similar to the Design of Experiments Seminar, this seminar on multivariate analysis techniques — core techniques in SQC — consists of two courses, which participants choose on the basis of the content that they wish to learn: the Introductory Course and the Practical Course. (The following outlines the content of the Practical Course)

[*Overview*] This course enables participants to master techniques that apply multivariate analysis, in the form of graphical modeling (GM) and structural equation modeling (SEM) for causal analysis.

[*Target Participants*] Individuals with a proficiency level equivalent to those who have completed the Introductory Course for Multivariate Analysis, who understand the basics of correlation analysis, regression analysis, and principal component analysis

[*Duration*] 4 days (2 days/month × 2 months)

[*Subjects*] Correlation and Causation; Fundamentals of GM; Spurious Correlation and Partial Correlation; Undirected Graphs; Using GM for Causal Discovery; Causal Analysis and Path Diagrams; Causal Models and Path Analysis; Direct Effects, Indirect Effects, and Overall Effects; the Reality of Causal Analysis Using SEM

One particularly noteworthy element of this course's curriculum is that participants can, if they so choose, consult the lecturer about the themes for improvement that they are tackling in their own work.

Taguchi Method Introductory Course

[*Overview*] The primary objective of this course is to provide an understanding of the basic concepts and techniques employed in the Taguchi Method. It introduces numerous examples of its application, enabling participants to gain practical skills in using the Taguchi Method.

[*Target Participants*] Engineers involved in technology, design and development, research, and quality control, and individuals who are interested in the Taguchi Method and understand the basics up to and including orthogonal arrays

[*Duration*] 2 days

[*Subjects*] Includes: Systems and Stability; Introduction to Parameter Design (using the example of n-type characteristics); Parameter Design of Dynamic Characteristics; Parameter Design at the Technology Development Stage; Parameter Design of Nonlinear Systems; Parameter Design Involving Non-measurable Inputs and Outputs; Other Design Activities Using Orthogonal Arrays; MTS; Taguchi Method and Development Process Re-engineering; Introduction to Examples

EDUCATION PROGRAMS TAILORED TO GROWING CONTEMPORARY NEEDS IN THE AREAS OF PATTERN RECOGNITION AND BIG DATA

Mahalanobis-Taguchi (MT) System Introductory Course

[*Overview*] This course enables participants to learn about the MT System, which is one Taguchi Method technique.

[*Target Participants*] Manufacturing industry staff working in departments engaged in inspection, testing, quality assurance, facilities management, or planning, individuals from the medical care and pharmaceuticals sectors, individuals from the software sector, and engineers, researchers, young academics, and graduate students involved in research and development in the fields of pattern recognition, multidimensional data processing, or multivariate analysis

[*Duration*] 2 days

[*Subjects*] Includes: What is MTS?; Pattern Recognition and MTS; Characteristics of MTS and Various Calculation Methods; Feature Extraction and Data Handled in MTS; Application Procedure and Key Points of the MT Method; Application Procedure and Key Points of the T Method; Introduction to Examples; MTS Issues and Anticipated Developments.

Data Science for Problem-solving in Manufacturing Introductory Course

[*Overview*] This course teaches participants about big data analysis for industry by means of exercises using free software.

[*Target Participants*] Practitioners in the field of manufacturing who want to use big data in their work and those who aim to become data scientists, etc.

[*Duration*] 5 days (Preparatory course: 1 day, then 2 days/month × 2 months)

[*Subjects*] Includes: Moment; Multiple Linear Regression Analysis; Principal Component Analysis; General Principles of Data Science; Density Plots; Complex Networks; Bayes' Theorem (up to the non-Bayesian methods using Dirichlet distribution and generative model approach); Classifiers and Discriminators; Kernel Trick (identification model approach); Data Cleaning; Regularized Regression (sparse modeling and penalized regression); Classical Graphical Modeling and Glasso (graphical lasso); Examples of Process Anomaly Detection; General Question and Answer Session

EDUCATIONAL OUTCOMES

The Quality Forum (Quality Management Conference) as a Forum for Presenting Case Study

JUSE has organized various initiatives and events nationwide every year since 1951, when it held the Quality Control Conference to Commemorate the Awarding of the 1st Deming Prize. Today, numerous presentations focused on quality case studies are given by companies and organizations from across the country at the Quality Forum (Quality Management Conference). A public call is made for the submission of examples of kaizen improvement using SQC and presentations are made by many of Japan's leading companies.

Last year (2017)'s forum was attended by more than 900 people, with a substantial program that encompassed two special lectures and reports by winners of the Japan Quality Recognition Award2), while eight rooms at the venue were given over to planning sessions and five to presentations of individual examples.

INTRODUCTION TO CASE-BASED EXAMPLES

QC Circle activities, which are small-group kaizen activities led by shop-floor staff, are one of the key characteristics of Japanese corporate activities. Statistical techniques are utilized in kaizen activities to improve productivity and quality. The following introduces two Case studies of such kaizen activities.

Helping to Improve Earnings by Reusing Analyzer Filters / Spring Circle in Higashi-Fuji Technical Center, Toyota Motor Corp.

An exhaust gas analyzer is needed to test the performance of engines and parts. This analyzer is susceptible to soot damage, so exhaust gas is passed through two filters on its way to the analyzer. The Spring Circle undertook a kaizen activity focused on reducing filter purchase costs by 50%. In this kaizen activity, the circle devised a means of recycling used filters. In checks of components and flow rates using the analyzer with the recycled filters, a control chart was used to confirm that there were no problems and the recycled filters performed as well as the new ones. (See Figure 2. Blast Furnace Regeneration)

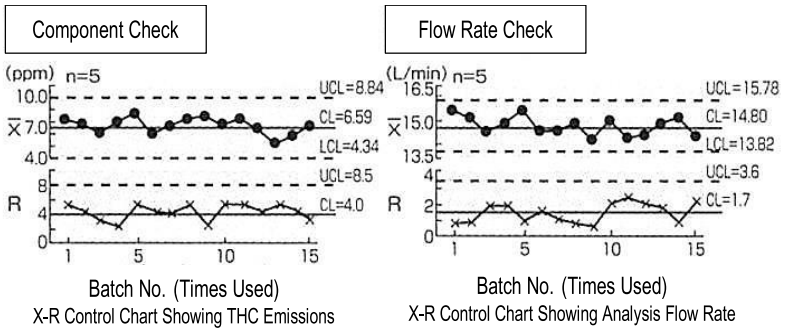

Figure 2. Blast Furnace

(Excerpt from QC Circle magazine, issue No. 595(2011))

Sand Mixing Equipment: Activity to Reduce Costs by Eradicating Defective Sand / Mechadoc Circle in Kanda Plant, Toyota Motor Kyushu, Inc.

Strength defects were occurring in the sand used as the foundry core in the cylinder casting process. The Mechadoc Circle took such steps as changing the sand heater temperature control method and achieved zero sand defects, but although the results were within the standard, there were variations in transverse strength. Accordingly, the circle formulated the hypothesis that the root cause of the variation in transverse strength was due to unevenness in the coating as a result of defective mixing of the resin used as a bonding agent for the sand with the hexa used as a curing agent. The circle used a scatter diagram and coefficient of correlation to test this hypothesis. (See Figure 3. Verification of the Root Causes of Variations in Transverse Strength)

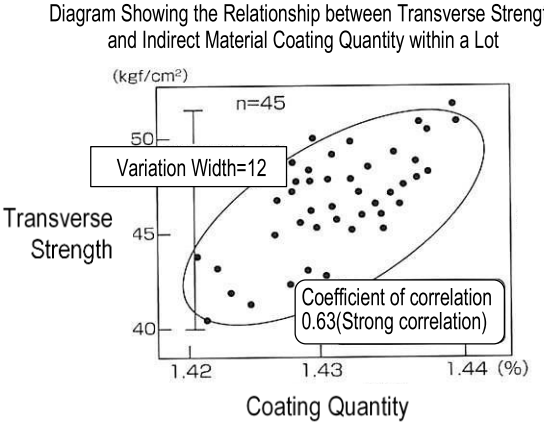

Figure 3. Verification of the Root Causes of Variations in Transverse Strength

(Excerpt from QC Circle magazine, issue No. 632(2014))

CONCLUSION

The statistical quality control education provided by JUSE has contributed to the cultivation of personnel to support TQM in Japan. These people played a central role in the deployment of TQM activities, which led to the improvement of the organizational capabilities of Japanese companies.

Note 1) Deming Prize: The Deming Prize was founded in 1951 to commemorate the friendship and achievements of the late Dr. William Edwards Deming, who laid the main cornerstone of postwar efforts to promote the widespread adoption of statistical quality control in Japan and to raise the quality standards of Japanese products to one of the highest in the world. It is the world's most prestigious prize in the field of Total Quality Management (TQM). (Deming Prize website: http://www.juse.or.jp/deming_en/)

Note 2) Japan Quality Recognition Award: The Japan Quality Recognition Award was established in 2000 to commemorate the 50th anniversary of JUSE's founding. It is positioned as a milestone on the path to the Deming Prize. There are two awards: Recognition of TQM Achievement and Recognition of Quality Innovation. Their objective is to produce outstanding companies and organizations that can succeed amid harsh global competition through the practice of TQM. (Japan Quality Recognition Award website: http://www.juse.or.jp/jqa/)

REFERENCES

Mechadoc Circle in Kanda Plant, Toyota Motor Kyushu, Inc. (2014). Case Study: Sand Mixing Equipment: Activity to Reduce Costs by Eradicating Defective Sand. *QC Circle magazine, 632*, 32-35

Spring Circle in Higashi-Fuji Technical Center, Toyota Motor Corp. (2011). Case Study: Helping to Improve Earnings by Reusing Analyzer Filters. *QC Circle magazine, 595*, 36-39.

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