AC 2011-1493: AN APPLICATION-BASED GRADUATE COURSE IN ADVANCED QUALITY TOOLS

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An Application-Based Graduate Course in Advanced Quality Tools

Abstract

This paper examines in detail the development of a graduate-level Manufacturing Engineering Technology course in advanced quality tools. All areas of modern industry have adopted a standardized set of tools and methods used in designing processes and communicating their performance. These cover a wide range of individual tools, from Process Failure Mode Effect Analysis (PFMEA) and Control Plans through the Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) to techniques such as 8 (or 9) Disciplines (8D or 9D) and related tools. These, combined with project management elements defined by the Six Sigma methodology such as Define, Measure, Analyze, Implement and Control (DMAIC) and Define, Measure, Analyze, Design, Verify (DMADV) can create a confusing jumble of alphabet soup in the minds of new practitioners, whether the tools are being used in health care, nuclear, manufacturing or process industries, or any of the many others segments which have adopted them.

From personal experience the author has seen the need for teaching fresh college graduates how to employ quality tools effectively, and has had to account for the time of the training curve in planning when new hires can start performing effectively with them. The present course combines research with practical application exercises to familiarize a class of graduate students with a collection of over a dozen of the more widely-used quality tools. Small teams of students were tasked to develop complete manufacturing processes for an assigned product and employ these tools in communication and interaction with their customer (played by the professor, a long-time industry veteran).

Every week a new tool was introduced and the teams incorporated it into their planning and reporting structures. At the end of the semester, each team gave a final presentation to the customer, utilizing as many of the tools as they determined to be appropriate. Some of these students had worked or were working at that time in industry. Their feedback was very positive and confirmed the need for such a class to expand their personal body of knowledge. This paper will describe the class and its evolution.

Introduction

Throughout his career in the automotive and electronic industries, the author has seen the role of quality in manufacturing change significantly. From the introduction of such basic tools as Statistical Quality Control – SQC (and its subsequent evolution into Statistical Process Control – SPC) to the Six Sigma philosophy and methodologies, "quality" has gone from something done because "the customer said so" to a corporate survival strategy. Many formal tools (such as those listed in the Abstract above) have been developed to standardize the concepts and vocabulary of quality.

In an informal survey of employers on three continents over a 25+ year career in manufacturing engineering in a variety of roles, including certified Six Sigma Black Belt, the author has heard countless stories of how bright young college graduates are not adequately prepared to use these tools. The employers note that it can require significant amounts of time to train newly-hired engineers to become comfortable and productive in a quality role. Within his department's Industrial Advisory Board (IAB), composed of local and regional business executives who provide strategic direction to the department's programs, the need for practical preparation of graduating students, particularly master's degree graduates, in the use of quality tools has been repeatedly stressed. Within the undergraduate curriculum is a course in Quality Management Systems. The description in the University Bulletin says *"[t]his course is focused on quality assurance systems, management philosophies, methodology, function and impact of quality systems in manufacturing operations. Development and application of statistical process control tools."* The IAB agrees that this is a good first step, but, especially in the case of graduate students, it is not sufficient to allow new graduates to "hit the ground running".

A search of universities for graduate-level quality courses has identified many courses similar to that described above. Many emphasize the mathematics involved in shop- and machine-level statistics. Others focus on the methodology of Six Sigma or Lean Manufacturing. No courses were found that took the approach of manufacturing engineers planning and communicating quality topics to their customers. That is the focus of the present course.

Methodology

This course originated as a manufacturing engineering technology graduate seminar, 3 credit hours in length. The course description in the Bulletin says *"This seminar will cover some of the advanced quality tools used in the manufacturing and automotive industries. The emphasis will be evenly divided between practical applications and theory. Upon completion of this seminar, students will have an understanding of how these tools are used and why."* It was first offered during the first half of the summer semester of 2010, 3 hours in the evening, two times a week. In response to the input of the IAB, the course emphasis was on the application of a variety of advanced quality tools used to plan, implement and communicate an effective quality program. The schedule of topics is shown in Table 1 below.

Topic
Introduction - Supplier Relationships and Requirements, Supplier Quality Manuals
8D
APQP/PPAP
QMS/QFD
Gage R&R, Control Plans
FMEA, DFMEA, PFMEA
FMEA, DFMEA, PFMEA
Process Maps
Process Capability
Preparation for final
DMAIC/DMADV
Lean
Final Exam

Table 1 - Listing of course topics

Due in large part to the scheduling of this class, the original course had only six students enrolled. Also due to the time the course was offered, three of them were recent graduates of the undergraduate MET program currently employed in their field and pursuing their master's degrees after work. The class was divided into three groups of two students each, one experienced in industry and the other a full-time student with minimal experience. They remained in these groups throughout the semester and worked together on their case studies. In this way, the more experienced mentored the others.

As the majority of students had an undergraduate background that mixed manufacturing and automotive engineering technologies, the case studies were designed around the situation of a supplier (the individual groups) communicating their overall quality plan with a major automotive customer (the instructor). Each group was assigned a particular family of friction parts to work on throughout the semester. The three parts families were 1) disc brake pads 2) drum brake shoes and 3) clutch friction disks.

Class assignments were focused on the tool of the day. For instance, rather than lecture about Supplier Quality Manuals, the instructor posted fourteen SQMs from a wide variety of industries (heating & air conditioning, automotive, heavy equipment, energy storage, nuclear and health care) and asked each student to choose any three, analyze them and report on the common elements found therein. After the parts were assigned to each group, the assignments were based more specifically on that product family. Real process data was used for Gage R&R and process capability studies. Other tools required that the students reverse engineer their parts to define FMEAs, process maps, etc.

Reference Materials

The class used Rath & Strong's *Six Sigma Pocket Guide*[1] and Besterfield's *Quality Control*[2] as textbooks and reference. Extensive additional material was provided by the instructor on the university's Desire2Learn (D2L) class website. This material represented a wide variety of industry segments, from nuclear energy to health care. The majority were related to the automotive industry, however. Students realized that, regardless of their origins, these tools were not specific to any one industry, but had universal applications. Over 250 such reference items were posted on D2L by the end of the course.

Class Progression

At each meeting, a new tool was introduced and added to their expanding toolboxes. During the first part of each class period, a lecture / class discussion / demonstration introduced the students to the material and described when, how, why and under what circumstances to use it. Then the groups gathered around their computers and applied the tool to their case studies. Due to the fact that some of the students had never been exposed to some of the industrial manufacturing processes involved with their products, certain approximations and assumptions had to be made to allow them to move forward. In the end, the final submissions had to be fully consistent with these assumptions.

Students were given the course schedule and were asked to research the tool for the next meeting. At random intervals, pop quizzes tested the effectiveness of their studies of a particular tool. These quizzes showed that the class members were performing well and doing their assigned research.

As the semester progressed, the case study folders became larger and the materials more complex. As the end of the semester neared, the teams, in their role as suppliers gave presentations to the rest of the class who assumed the role of customer representatives (purchasing, engineering, etc.). The instructor assumed the role of the main decision maker at the customer organization, the person who would decide whether or not to purchase from that supplier. Debriefing followed the presentations to show the teams potentially more effective ways to present their materials and to reinforce good presentations.

The final exam involved each student, acting individually, using the quality tools and preparing a complete set of documentation such as a supplier would submit to a customer. Each of the tools was represented appropriately in their documentation. Process performance data was supplied in spreadsheets to the class members for tasks such as determining process capability and gage repeatability & reproducibility (Gage R&R) studies. FMEAs, process maps and control plans were prepared consistent with the processes defined in the teams' earlier studies.

Results

Formal assessment tools are difficult to apply to such a small group and with only one offering of the course to date. The students who were employed reported that they started using many of the tools even before the semester was over. Those who were graduating and actively interviewing reported that the use of these tools came up when talking with company recruiters and that they were able to discuss them intelligently. Despite the poor economy, each of these students had suitable job offers extended to them as a result of these interviews. In follow-up discussions with two of those employers, favorable comments were received regarding the ability of these students to move right into their new jobs and start performing well.

From its start as a manufacturing engineering seminar, this course was well enough received by students, their employers and members of the IAB that it has now been added to the graduate catalog with its own course number.

Bibliography

[1] Six Sigma Pocket Guide, Rath & Strong, 2006, http://www.rathstrong.com/publications.htm

[2] Quality Control, 8th Edition, Besterfield, Dale H. 2009, Pearson Prentice Hall, ISBN-13:978-0-13-500095-3