# A Comparison of Industrial and Academic Perceptions of Quality Control Education





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Effective quality control is easily recognized as a key component in successful manufacturing operations. Companies place a high priority on establishing a strong quality management team and sound quality procedures, yet many employers find newly hired technical graduates unprepared to apply quality control concepts learned in the classroom. Companies realize that the success of their quality program has a substantial influence on their bottom line. Quality program effectiveness is directly related to profitability through its impact on productivity, product cost, customer satisfaction, product image, and, ultimately, attainable product price. Considerable resources are spent on either training existing employees or hiring additional ones who are well versed in quality control principles.

Educators in technical programs share in this concern for developing well-trained graduates who are competent in a variety of quality related topics. Technology-based programs typically include one or two courses focused on quality topics. As in industry, educators spend a great deal of resources and effort developing appropriate quality related courses, faculty, and facilities.

The purpose of this study was to investigate the perceptions of both industry professionals and faculty members of technology-based programs concerning the preparedness of recent graduates as they began a quality related position. To gain this information, surveys were administered among managers and technical leaders in industry and compared with surveys of faculty members from four-year industrial technology and engineering technology programs. Recent graduates were evaluated with regard to both theoretical knowledge and applied skills. By analyzing survey results, recent literature, and in-depth conversations with industry professionals, recommendations are made for improving quality control curricula and better serving industry needs.

## Background

Quality control on the plant floor is practiced much differently than it is presented in the classroom, with numerous opportunities for inaccurate data collection and unclear conclusions (Schenck, 1993). Experienced quality professionals often find that newly hired graduates have difficulty with issues such as gaging, data interpretation, and conforming to a production and cost-oriented environment. While many of these issues are a matter of experience, both industry professionals and the related literature indicated that applied quality concepts should be added to basic quality control curricula at the college level. Every effort should be made to strengthen students' skills by combining theoretical knowledge with practical situations (Kemenade & Garre, 2000).

Successfully applying quality control concepts on the shop floor requires the ability to overcome common problems such as incomplete data, inaccurate measurements, and non-normal distributions. Dealing with these types of problems can be challenging for those who have been exposed to rigid statistical standards for quality analysis in the classroom. Wheeler and Chambers (1992) indicated that many techniques can be used even when less than perfect conditions such as non-normal distributions and unstable processes exist. In addition, an understanding of the ways in which the process and product impact the analysis of quality data is critical in making correct judgments (T. Dorsey, personal communication, June 6, 2003). Familiarity with basic data collection procedures and protocols, along with an understanding of quality standards and reference material, is also expected. These requirements may seem overwhelming for those in entry-level positions, but exposure to a few key concepts before graduation can make the transition much easier. Demanding production schedules and cost constraints can be additional complications for the quality professional to overcome. The key to success is an ability to understand and address these problems without abandoning basic quality theory and standards.

## Previous Work

Previous studies have investigated methods for improving quality control skills of employees. Rungtusanatham (2001) surveyed production personnel to assess the impact of quality control training. His findings indicated an improvement in motivation and job performance as quality control skills increased. Improved quality control practices by employees also have an impact on customer satisfaction according to Nilsson, Johnson, and Gustafsson (2001). Suleiman and Yourstone (1998) investigated the effects of training, performance evaluation, and rewards on the successful implementation of a quality management program. Developing a sense of value for quality among workers is of particular importance. Deming (1994) concluded that external monitoring or bonuses are not the basis for an effective quality system. Instilling a value of quality for its own sake based on the pride and self-esteem of the workers results in long-term success. A survey conducted by Rao, Raghunathan, and Solis (1997) indicated that quality assurance performance was affected by length of quality experience in organizations.

Folkestad, Senior, and DeMiranda (2002) explored service learning as a method for developing students' social attitude toward work along with strengthening technical literacy. This method does hold some promise for strengthening practical skills by increasing exposure to real projects with real problems. However, caution should be exercised to assure that the technical content of the project is demanding enough for the particular course of which it is a part. Focusing on social development in a technical course could reduce exposure to and comprehension of specific skills that will be needed later. Plaza (2004) proposed an integrative approach to technology education in which core courses are developed around a topic involving many disciplines and many instructors. This approach could be successful at the introductory or capstone levels, but could also trend toward an excessive number of survey courses that would reduce the focus and depth of the program.

Bhote (1991) concluded that 90% of U.S. industry is not successful in solving chronic quality problems. He promoted the teaching of very powerful, but simple, statistical tools for dealing with persistent problems.

The previous studies have indicated that quality control training can have a positive impact on employee performance. With a grounding in these findings, this study sought to determine specific quality skills employers expect in entry-level professionals. A comparison of what is expected by employers versus what is emphasized by academia was then investigated.

## Survey Methodology

Both industry professionals and college faculty members were surveyed to gauge and compare expectations concerning quality control education. A questionnaire survey instrument was developed and a pilot test was conducted with colleagues and industry professionals who had significant roles in quality control. The pilot test was conducted to check the validity of the questionnaire, identify and eliminate any ambiguity, and make appropriate changes identified by respondents' suggestions. Recommendations from the pilot test were incorporated into the final version of the survey and included issues concerning specific topics covered, wording of certain questions, and the form of the survey itself (see Figure 1 for the final version of the survey questionnaire).

Two populations were targeted for the survey. One population consisted of a database of industry professionals maintained by the college department conducting the survey. This database was made up of production and quality assurance professionals who maintained contact with the department and had involvement in applying quality control concepts in the national or international manufacturing environment. A second population consisted of college faculty who were members of the engineering technology listserv, which included technology-based faculty across the United States. A qualifying statement with the survey narrowed this population to faculty of four-year industrial technology or engineering technology degree-granting institutions who were involved in teaching quality control. All surveys were sent via e-mail.

The survey employed twelve 5-point Likert scale questions and one rank order type question. The 5-point Likert scale design consisted of: (1) strongly disagree, (2) disagree, (3) undecided, (4) agree, and (5) strongly agree. The achievement of new technology graduates was evaluated with respect to six knowledge areas in quality control: basic statistics, statistical process control, measuring equipment, non-normal distributions, gage control, and documentation standards. Each knowledge area was evaluated using a paired format consisting of a

**Figure 1. Survey questionnaire.**

The following survey questions relate to recent college graduates from four-year Industrial Technology or Engineering Technology programs entering the industrial workforce. Assume that the graduates will be significantly involved with the quality control function in their first assignment.

Do recent graduates from technology based programs possess the following knowledge and skills? Check one of the five boxes for each knowledge or skill listed.

| | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| Graduates have adequate knowledge of basic statistical theory | | | | | |
| Graduates have adequate skills in applying basic statistical concepts | | | | | |
| Graduates have adequate knowledge of statistical process control theory | | | | | |
| Graduates have adequate skills in applying statistical process control concepts | | | | | |
| Graduates have adequate knowledge of basic measuring equipment | | | | | |
| Graduates have adequate skills in using basic measuring equipment | | | | | |
| Graduates have adequate knowledge of non-normal distributions | | | | | |
| Graduates have adequate skills in applying non-normal distributions to analyze data | | | | | |
| Graduates have adequate knowledge of gage control concepts | | | | | |
| Graduates have adequate skills in applying gage control concepts | | | | | |
| Graduates have adequate knowledge of data collection and documentation standards | | | | | |
| Graduates have adequate skills in applying data collection and documentation standards | | | | | |

Of the following quality related areas, rank the top three items (1, 2, 3; 1 = highest priority) that you feel most need **additional** attention in technology based programs. If an item is not listed please write it in the space provided. **Only select the top three items – leave all others blank.**

___Statistical Process Control ___Gage Control ___Design of Experiments

___Basic Statistics ___Capability Studies ___Measuring Equipment

___Data Collection Standards ___Economic Aspects of Quality ___Hypothesis Testing

___Non-Normal Distributions ___Rational Subgrouping ___Sampling

___ ____________________ (list an additional item if not given) statement relating to theory and a second statement relating to applied skill.

The rank-order portion of the survey listed 12 items for the participants to consider. A blank was provided that allowed an additional item to be added if it was not already listed. Participants were asked to rank the top three quality control items (1, 2, 3; 1 = highest priority) that they felt most needed additional attention in technology-based programs. This portion of the survey was evaluated by applying a number score to the ranked responses. For clarity this priority scale was then inverted. Quality control items rated with the highest priority were assigned a score of 3 followed by 2 and 1 for lower priority rankings. In this way graphical priority ratings may be more easily interpreted.

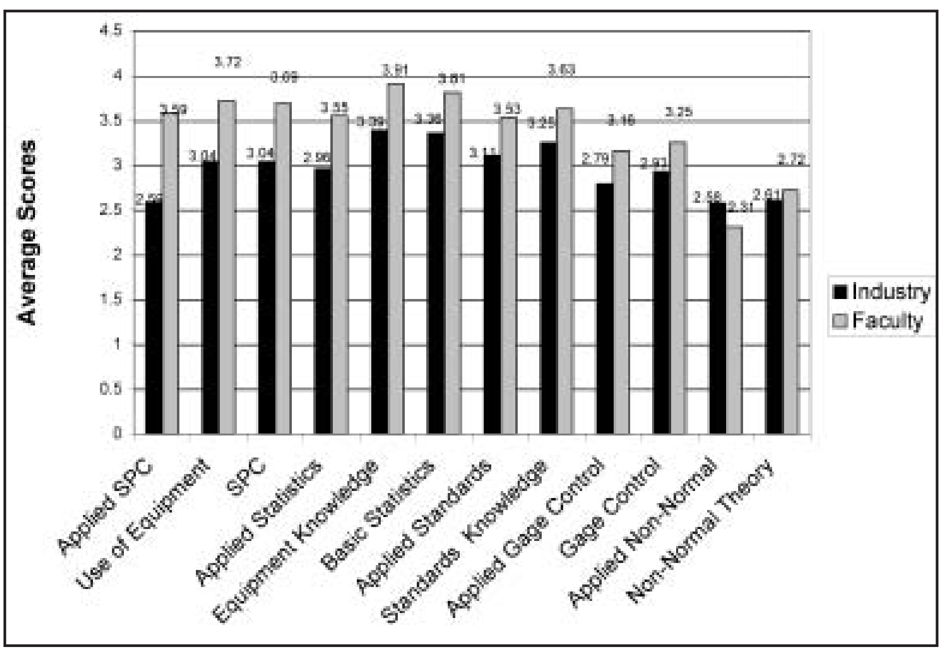
A total of 28 useable questionnaires out of 64 were returned by industry professionals for a response rate of 44%. Three industry questionnaires were discarded due to incomplete responses. A total of 32 faculty members returned surveys from an original population of approximately 175 for a response rate of 18%. One faculty questionnaire was discarded due to improper ranking of items in the rank order portion. The faculty response rate was approximated based on the engineering technology listserv membership of 1,396 for four-year colleges. A spot check of five institutions revealed that about 1 out of 8 faculty members from technology-based programs were involved in teaching quality control courses. This reduced the target population to approximately 175.

The Likert portion of the survey strongly indicated the rejection of the null hypothesis associated with the means test indicating the sample sizes were sufficient to identify differences between the two groups (see survey results). The rank order portion of the survey revealed that approximately half of the respondents chose the top three ranked items. According to Cochran (1977), a minimum sample size of about 30 is needed to ensure validity if the population proportion is approximately 0.50. Based on the above guidelines, we would classify any conclusions drawn from the study to be cautiously valid.

### Survey Results

The survey was intended to evaluate the abilities of recent graduates from two different perspectives: industry and academia. The first part of the survey consisted of 12 statements that were rated according to the Likert scale previously described. In comparing the two survey groups, we examined which knowledge areas exhibited significantly different responses between industry professionals and college faculty. To illustrate this comparison, data from both groups were summarized in a single bar graph and listed in descending order of differential magnitude (see Figure 2).

**Figure 2. Combined bar chart for knowledge area ratings.**



The greatest difference between ratings scores occurred in the applying SPC category. A large difference in ratings also occurred in evaluating knowledge of SPC. This is surprising considering the attention and effort expended on this topic by both industry and academia. Other areas that showed a large difference between the two evaluation groups include knowledge and use of equipment, statistical theory, and applying basic statistics. The overall evaluation of recent graduates' knowledge and abilities is noticeably lower from the industry professionals averaging 2.97 compared to the college faculty group which assigned an average score of 3.41. In order to determine whether the differences in ratings between industry and academia were statistically significant, a means test (*t* test) was performed for each knowledge area. The results of these tests are shown in Table 1.

Table 1 indicates a statistically significant difference between industry and academic ratings for SPC theory and application, equipment knowledge and use, and applying basic statistics. In all of these categories the faculty ratings were significantly higher than the industry ratings.

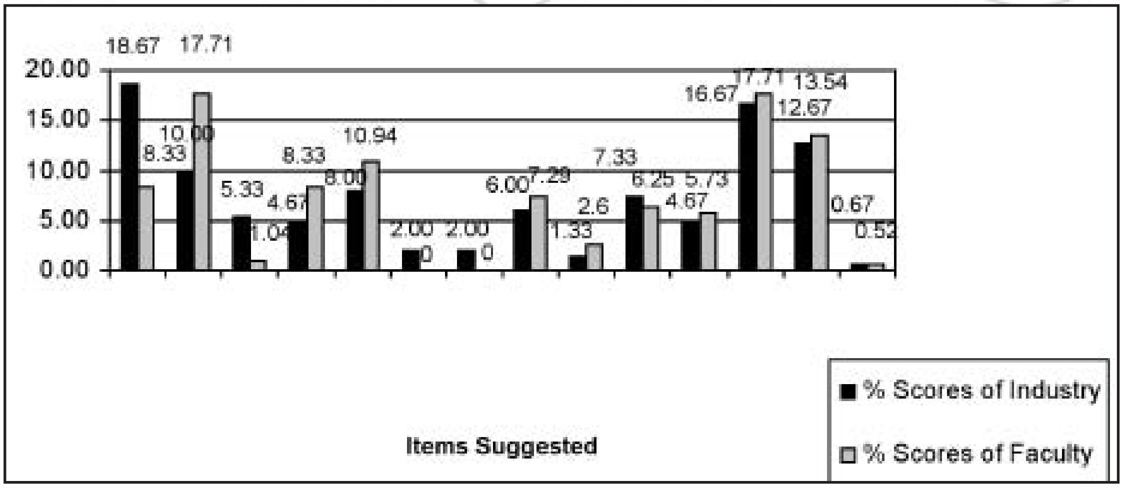
The rank order portion of the survey was designed to identify the most crucial topics that

**Table 1. Means Tests for Theory Versus Academic Ratings**

| Knowledge Area | Means Industry | Means Faculty | *t* Value | *p* Value |
|---|---|---|---|---|
| Applying SPC | 2.59 | 3.59 | -4.16 | .000* |
| Use of equipment | 3.04 | 3.72 | -2.88 | .006* |
| SPC theory | 3.04 | 3.69 | -2.51 | .015* |
| Applying basic statistics | 2.96 | 3.55 | -2.13 | .037* |
| Equipment knowledge | 3.39 | 3.91 | -2.32 | .024* |
| Basic statistical theory | 3.36 | 3.81 | -1.82 | .074 |
| Applying standards—data collection and documentation | 3.11 | 3.53 | -1.63 | .111 |
| Standards knowledge—data collection and documentation | 3.25 | 3.63 | -1.41 | .166 |
| Applying gage control concepts | 2.79 | 3.16 | -1.47 | .148 |
| Gage control theory | 2.93 | 3.25 | -1.24 | .222 |
| Applying non-normal distribution theory | 2.58 | 2.31 | 1.08 | .287 |
| Non-normal distribution theory | 2.61 | 2.72 | -0.43 | .669 |

*Note:* *t* test of mean differences = 0 (vs. = 0).
*Meets significance level with *a* = 0.05.

**Figure 3. Combined chart for areas needing further attention.**




should receive additional attention in technology-based programs. A bar chart was constructed to illustrate the difference in responses for industry professionals compared to college faculty. The chart shown in Figure 3 lists response differences in descending order of magnitude for all rank order data. The scoring for areas of study needing further attention was noticeably different between industry and faculty responses. Industry scored capability studies and SPC highest (most in need of further attention) while faculty members indicated SPC and design of experiments (DOE) should receive the highest priority. Both groups listed basic statistics among the top three items. Due to the scoring method and an unequal number of participants in the two groups, the raw score was converted to a percentage of the total possible score for each group. A means test was not feasible for the rank order portion of the results due to the complicated scoring method.

## Analysis of Survey Results

The fact that recent graduates' overall skills in quality control were rated significantly lower by industrial professionals than by faculty members may indicate a disconnect between the two groups. Increased interaction and communication between the groups could be helpful in bridging this gap. The greatest differential was assigned to applying SPC skills. SPC is taught as a part of most technical programs and has been recognized as a key quality concept for decades. With great focus on this topic, it is troubling that such a gap exists between industry and faculty perceptions. Applying knowledge to industrial situations requires judgment and experience that students often do not receive in the classroom. Although this reality is inevitable to some degree, additional classroom projects and laboratory exercises could help address the problem. Perceptions concerning graduates' understanding of SPC theory, knowledge of common equipment, ability to apply basic statistics, and ability to use equipment all indicated a statistically significant difference between industry and faculty ratings. Most of these abilities require the application and practice of theory. The survey results indicate that faculty members may need to focus much more on developing the practical, applied skills of students in order to meet industry expectations.

The rank order portion of the survey identified differences in ratings concerning areas of study needing further attention. Both industry and faculty strongly indicated that SPC and basic statistics should receive more attention in technology-based programs. Industry professionals identified capability studies as the most crucial area for additional coverage whereas faculty members' evaluation of this topic was much lower. The ability to perform and understand capability studies is a critical part of most quality control functions. Industry professionals seemed to indicate that specific, practical skills such as this are very valuable and need much more attention in the academic environment.

Faculty members indicated that DOE should receive much more attention in academic programs whereas industry professionals rated this area much lower. DOE has been touted, and used to a lesser extent, in industry for many years. Being a more complex area of study, it requires a strong statistical background to be fully utilized. Many in industry who have taken DOE training may still lack the statistical skills to apply it effectively. This may explain the lower ranking assigned by industry; however, the importance of DOE has been clearly established. Montgomery (2001) and Roy (1990) have demonstrated the practical value of applying DOE in industry using various factorial techniques.

## Analysis of Industry Concerns

The results of the survey reveal industry concerns and needs that should be further explored. If academic programs are to be improved, specific experiences and abilities that are lacking must be identified and integrated into industrial technology and engineering technology curricula. To address these issues, in-depth discussions with industry professionals were conducted. The issues identified during these discussions were very similar to those highlighted by the survey. In addition, a review of recent literature and teaching strategies was conducted. The conclusions drawn from these efforts follow.

*Capability studies:* The survey identified capability studies as a major area for improvement. An understanding of how to conduct and interpret these studies is a crucial basic skill in industry. Students are often exposed to the formulas and methods for calculating $C_p$ and $C_{pk}$ without gaining a clear understanding of the meaning and importance of the numbers being generated. Exposure to one-sided specifications, non-normal distributions from specific processes, and data collection methods as a part of process capability studies can help strengthen students' skills (T. Dorsey, personal communication, June 6, 2003).

*Statistical process control:* Both faculty and industry surveys indicated that SPC should receive more attention in technology-based programs. Most quality control courses include a study of SPC involving theory and textbook problem solving. This level of exposure may not require enough practice or development of applied skills as the industry survey indicated. Addressing applied skills in SPC provides an excellent opportunity for faculty members and students to interact with local industry. Student projects that involve interaction with local manufacturers and data collection from real processes can greatly increase applied skills (K. Hubbard, personal communication, March 10, 2004).

*Relating process and product to quality:* Before any quality control study begins, a clear understanding should exist of the process and product from which the data are to be drawn. Most quality control training in the classroom includes statistical analysis, control charting, and basic procedures without emphasizing how characteristics of the particular process and product can influence the results. Without making this important link, opportunities for error and misinterpretation are endless. Errors involving incorrect subgrouping of data are particularly common in industry (Wise & Fair, 2001). Non-normal distributions are common among many processes such as the wear cycle associated with drilling processes (Oberg, Jones, Horton, & Fyffell, 2000). Exposing students to realistic process characteristics such as this example can strengthen their skills as they begin their careers (T. Dorsey, personal communication, June 6, 2003).

*Gage repeatability and reproducibility:* When collecting data for analysis, assuring that accurate gages and gaging methods are used is a critical first step. Incorrect use of common measuring devices such as calipers and micrometers can be a particular problem (Hewson, O'Sullivan, & Stenning, 1996). Measuring equipment and processes must be well controlled and suited for the particular use in order to assure valid data collection (Little, 2001). Students who receive little or no practical experience with measuring devices have difficulty in understanding the seriousness of this issue. Given that inaccurate gages and gaging methods are common problems in industry, a strong argument can be made for strengthening gage control coverage at the college level (N. Anderson, personal communication, June 4, 2003). Hands-on projects involving gage repeatability and reproducibility (R&R) studies and gage control allow students to integrate knowledge with practical situations, strengthening needed skills in the process (Kemenade & Garre, 2000).

*Standards for data collection and sampling:* Complying with appropriate sampling procedures and documentation practices is critical in most quality control studies. The sampling method should contain enough data to conduct a complete analysis without the collection of unneeded information that distracts when drawing conclusions (Carey, 2002). An introduction to quality standards and procedures can help better prepare students to address issues such as correct sample size and sample identification, appropriate sampling procedure, and documentation requirements (N. Anderson, personal communication, June 4, 2003).

## Recommendations

Based on the survey results, discussions with industry professionals, and literature review, the following recommendations are made concerning the improvement of quality control education:

- *Improve interaction between industry and academia.* The survey indicated a significant difference in responses from industrial professionals as compared to those from faculty members. Improved communication and exchange of ideas between the two groups is needed. By implementing an industrial advisory board, technology-based programs can take an important step toward this goal. Advisory boards made up of local and regional industry leaders can provide invaluable information concerning what is needed and expected of graduating students. This forum also allows faculty members to introduce ideas and methods that are not well known to industry. Other contacts with industry through student internships and funded research can be quite helpful in keeping the communication lines open. Industry interaction with student organizations through plant tours, guest speakers, and assistance with student projects can also prove beneficial.

- *Increase coverage of statistical process control and capability studies.* The survey strongly indicated that both industry and faculty recommend additional coverage of SPC and process capability analysis. Industry evaluation of recent graduates' applied SPC skills was particularly low. To compensate for this lack of applied skills, additional theory coverage should be combined with a "hands-on" laboratory component requiring process monitoring and interpretation. Realistic problems and complications associated with SPC and process capability that are likely to be experienced in industry should be discussed and included in assignments.

- *Emphasize the combination of practical application with theory.* The industry survey indicated significantly lower ratings for equipment knowledge, equipment use, applying basic statistics, and applying SPC as compared to the faculty survey. These applied skills appear to be lacking as graduates begin their careers. This shortfall can be improved by further emphasizing applied skills and practical application in combination with theory. Examples presented earlier that can lead to the development of applied skills include dealing with complications such as one-sided specifications, using common equipment to measure and collect data, conducting capability studies, SPC monitoring, performing gage R&R studies using real parts and data, and locating and using data collection and sampling standards. These few examples are representative of numerous opportunities for gaining practice and experience in applying theory. Many of these activities can be implemented in the classroom. If additional laboratory time is needed, it should be added into the curriculum.

- *Promote the introduction of new methods and techniques in industry.* New techniques and methods of analysis are often developed and perfected in academia, not industry. More complex methods of analysis and process improvement may not easily be introduced into industry. Although DOE techniques have been used for many years, they are still valued much more in academia than in industry according to the survey. These more advanced methods may require additional support and interaction with industry from college faculty, and may be further introduced by supplying graduates with significant training in these areas. Comments and opinions should not only flow down from industry to academia, but also flow up as education develops new or complex ideas and methods that can benefit industry.

## Summary

Industry respondents evaluated recent graduates' knowledge and abilities in quality control significantly lower than the same evaluation provided by college faculty. Industry professionals and college faculty have different opinions concerning which areas of study should be further emphasized to improve quality control education. By improving the dialogue and interaction between industry and academia and implementing a more applied education, the quality control component of industrial technology and engineering technology programs can be greatly strengthened.

### Future Research

An important finding in this study was the disconnect between industry and academia concerning which quality control skills most need further emphasis in technology-based degrees. A comparison of student skills after completing a more traditional lecture-based course versus a more applied course as suggested by this study would be of interest. This information could help determine the potential for improving quality control skills by revising course content and structure.

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