

## **AC 2007-688: A SHORT COURSE IN UNDERSTANDING PRINTS FOR AUTO MANUFACTURING PLANTS**

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A registered professional engineer and member of Pi Tau Sigma Mechanical Engineering and Tau Beta Pi Engineering honor societies, Dr. Rathod is active in American Society for Engineering Education (ASEE), ASHRAE, American Society of Mechanical Engineering (ASME), Professional Order of Engineering Technology (POET), Society of Manufacturing Engineers (SME), and Tau Alpha Pi (TAP) National Honor Society for Engineering Technology. He founded student chapters of SME, TAP, and ASME at SUNY-Binghamton and WSU, and lead as faculty advisor. He served in leadership roles of MET Department Heads Committee of ASME and organized first paper session on applied research. Also, he has served on ASME Boards (Engineering Education, Minorities and Women (Vice President), Diversity and Outreach (Vice President), Metrication, and Regions III and V Operations); Councils (Education, Public Affairs); and representative to Technology Accreditation Commission (TAC) of Accreditation Board for Engineering and Technology (ABET).

Dr. Rathod has been the ASEE campus representative at WSU. He has served on the editorial board of the Journal of Engineering Technology and was its advertising editor. He was a director of the ETC board of ASEE He has been a reviewer for the journals of ET, ASHRAE, and Engineering Education, and has served on several proposal review panels of NSF and other organizations. He has organized and chaired paper sessions in the professional societies and served as a commissioner on the TAC of ABET.

The founding leader of POET, Professor Rathod is a holder of numerous publications, inventions, and grants. He is listed in several Who's Who publications, and is a recipient of Certificates of Recognition from NASA and IBM for technical innovation. Elected a Fellow by ASME, Dr. Rathod was awarded 1995 Dedicated Service Award, 1998 Ben C. Sparks Medal, and 2001 BMW award by ASME.



# **A SHORT COURSE IN UNDERSTANDING PRINTS FOR AUTO MANUFACTURING PLANTS**

## **SUMMARY**

In an environment of global competition, auto manufacturers, labor unions, and educators are in a complete agreement on the need to encourage and promote ongoing learning in the general area of quality improvement. With that understanding of changing paradigm, a set of courses leading to certification of quality professionals was developed for an auto manufacturer. Implementation of this specialized training program required commitment on the part of union membership and corporate leadership. This paper describes one of the short courses in understanding prints and requirements for technical as well as non-technical professionals for an automotive industry.

The course covered topics in print reading, shapes and views, sectional views, dimensioning, tolerances, holes and threads, surface texture, geometric dimensioning and tolerancing (GD&T), and print identification and specifications. A heterogeneous group of participants included persons with no technical background, some with skilled trades training, and a few with engineering degrees. At the conclusion of the course, an examination was administered and each participant also completed course and instructor evaluation as a part of outcomes assessment.

This paper describes the course contents, teaching pedagogy, lessons learned, and participants perceptions of learning. It covers improvements made in the course contents and delivery as a result of participants' assessment of the course and program. In addition, this paper would provide a template for others to carry out similar training in industrial and manufacturing setting for a heterogeneous group..

## **INTRODUCTION**

The US industrial infrastructure is going through transformation that is threatening sustainability of the current workforce. This deviation is happening faster than many experts had anticipated. Some changes are making a profound impact on the workforce and the economic outlook of various regions in the country. The state of Michigan is a hot bed of well paying skilled trades for workers in the automotive industry which is very much challenged by the onslaught of international car companies. The whole industrial base is definitely impacted by the rapid changes taking place in the global economic scene.

There is a need for the state of the art continuing education for workers at all levels, in the fast changing world of science and technology. It is the responsibility of universities and community colleges to prepare our workforce so that it would continue to prepare talented artists, technicians, professionals. Industry and academic institutions must join hands in keeping the workforce relevant by providing the latest tools and techniques.

This paper would briefly address some teaching and learning models, would focus on

contents and organization of the short course, and pedagogical issues. Attendee input on the processes and outcomes along with their critique would provide an assessment tool. Finally, it would provide recommendations and conclusions on organizing similar short courses and trainings.

## **TEACHING PEDAGOGY**

The traditional lecture is the most common teaching method used in higher education. It is known to be a very efficient technique in covering and presenting a large amount of information to a large number of students. It is also known that simple presentation of information does not constitute good transfer of knowledge from the teacher to the learner. The techniques and material expected to be transmitted should be useful to students and must be retained in the long term memory. At the same time, the students should be able to generalize that knowledge gained to other and similar situations.

There are a number of instructional methods being developed and practiced in higher education as a means of changing the traditional teaching methodologies [1-13]. Some of these include cooperative learning, case based teaching, writing across the curriculum, and writing to learn. A large number of these techniques can be categorized as active learning where students are involved in more than listening.

In the arena of short courses and trainings, programs should provide students with sufficient knowledge to adapt to the latest technologies. In the USA, it has been a common practice to provide state of the art training to employees at all levels under the title of quality improvements, total quality, continuous improvement, etc [14-24,26,28]. This is interwoven with the fundamental need to adapt to changing environment.

The design and delivery of the short course in understanding prints and requirements used similar examples and models as a foundation. A joint team of experts from automotive industry administration and labor union provided specific guidelines for course contents, delivery, and assessment. That team developed a series of courses under the title of advance certification for quality professionals as a part of quality network for this training [24]. Understanding prints and requirements was one of the courses in the professional development curriculum for certifying technical and non-technical as well as hourly and salaried employees. .

## **THE COURSE**

Table 1 shows day by day agenda as well as topics covered in the short course [24]. The contents were based on a number of sources dealing with the topic areas and some based on specific application needs of automotive industry [25-27, 29-32]. The course was divided into ten modules containing print reading, shapes and views, sectional views, dimensions, tolerances, holes and threads, surface texture, GD&T fundamentals and applications, and print identification and specification. Each module was further broken into lessons and at the end of each module, there were application exercises. Some exercises required independent work and some involved peer collaboration. After the students practiced the questions, instructor reviewed the answers and invoked discussions based on particular applications to participants' plants.

This course was initially scheduled to meet for two days (16 hours) and did not have any drawings from automotive plants. Each participant received a binder containing textbook and workbook which served as an excellent resource compared to a traditional textbook [24]. The authors provided a number of examples and useful collection of data. It benefitted the readers well with lot of details and historical evolution GD&T information. One drawback in the original workbook was that it lacked plant specific exercises and applications.

## **LEARNING ENVIRONMENT**

The author taught five sessions with enrollments varying from seven to seventeen participants. The training was offered at the Center for Human Resources (a UAW GM facility) in Detroit, Michigan. It is one the best facilities for educational and training. Class rooms were equipped with the state of the art multimedia equipment including a computer, camera, and projector. Also provided were easels with large charts for group discussions. Participants were seated around a number of round tables in groups which provided conducive environment for collaborative learning and exchange. Attendees came from different GM and Delphi facilities from all over the country.

As mentioned earlier, at the end of each module, groups or individuals would work on exercises and applications related to specific automotive plants. The drawings were proprietary and the instructors had to be careful to keep them confidential for the purpose of training.

Upon completion of all the course modules, a summary review of important issues and topics was carried out by the faculty. Then the participants were given quiet time individually to go over the material on their own before administration of the examination containing forty multiple choice questions. Following the closed book exam, participants completed an outcomes assessment survey covering course material, faculty, and the certification program as shown in Table 2.

To achieve familiarity with a lot of information and in many cases new topic, it was important to expose learner to the subject matter at least three times to embark into their long term memory. To be successful in the course, each attendee had to score 70% in the exam which was graded by someone other than the teacher. Those, who did not achieve passing grade, were helped later by teacher via tutoring until they were successful. In a total of five sessions, there were four or five such occurrences.

## **LESSONS LEARNED**

After all, the important purpose of the short course was to make individuals familiar with various technical terminology of engineering drawings and prints. Faculty member teaching the course should bring prior experience in industry to make the teaching and learning more exciting and inviting. As a part of the evaluation process, student input was the utmost important instrument. Table 2 shows a summary of responses which were computed based on 4.00 scale being the perfect. It shows generally positive outcomes and experiences for the participants.

Initially, all the exercises were academic in nature. Based on the input from first session,

it was decided to include applications and exercises derived from real products and parts from various GM plants. Since those drawings were proprietary in nature, it was necessary to share outdated parts and products. Participants were very much satisfied with those plant specific examples.

## **CONCLUSIONS**

For teaching a very technical short course to a heterogeneous group of workers with non-technical and technical background was a challenge. Active learning involving group discussions, multi media presentation, and application exercises kept learner interest in the subject matter and multiple exposure improved their chances of subject matter retention in the long term memory. In short, it was a successful teaching and learning experience.

## **ACKNOWLEDGMENTS**

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## **REFERENCES**

1. Pabbati, P.V., Rathod, M.S., "A Study of Curriculum Models That Integrate Mathematics, Physical Sciences, Computers, and Communication in Technical Courses," ASEE Annual Conference Proceedings, June 1995.
2. Latorre, R., Hatamura, Y., Ohashi, H., "A New Mechanical Engineering Curriculum at the University of Tokyo," Journal of Engineering Education, ASEE, pp 124-129, April 1994.
3. Litwhiler, C.D.W., Kiemele, M.J., "TQM and DOE in an Undergraduate Curriculum: Success Stories," Journal of Engineering Education, ASEE, pp 147-151, April 1994.
4. Waks, S., "A Methodology for Determining Engineering curriculum Contents," Journal of Engineering Education, ASEE, pp219-229, July 1994.
5. Bordogna, J., "Engineering Education: Innovation Through Integration," Journal of Engineering Education, ASEE, pp 3-8, January 1993.
6. Cherrington, B.E., "An Integrated Approach to Graduate Education in Manufacturing Systems- The U.T. Dallas Model," Journal of Engineering Education, ASEE, pp 43-47, January 1993.
7. Project Impact: Disseminating Innovation in Under Graduate Education, Abstracts of Projects, National Science Foundation, 1994.

8. Shuman, L.J., Besterfuekd-Sacre, M., McGourtly, J., "The ABET "Professional Skills" - Can They Be Taught? Can They Be Assessed? ASEE Journal of Engineering Education, v 94, n 1, January 2005.
9. Felder, R.M., Brent, R., "Understanding Student Differences," ASEE Journal of Engineering Education, v 94, n 1, January 2005.
10. Smith, K.A., et al, "Pedagogies of Engagement: Classroom-Based Practices," ASEE Journal of Engineering Education, v 94, n 1, January 2005.
11. Bourne, J., Harris, D., Mayadas, F., "Online Engineering Education: Learning Anywhere, Anytime," ASEE Journal of Engineering Education, v 94, n 1, January 2005.
12. Rathod, M.S., "Improving Learning Outcomes of a Course in Instrumentation," Paper # IMECE2006-13589, Proceedings of ASME IMECE 2006 Chicago, IL, November 2006.
13. Rathod, M.S., "Ergonomics of Learning in a Very Descriptive Applied Human Factors Course," Proceedings of ASME IMECE 2005, Paper # IMECE2005-79719, Orlando, FL, November 2005.
14. Rathod, M.S., Sheyman, V. "Addressing the Alternative Energy Workforce Needs," Proceedings of ASEE Annual Conference, Portland, OR, June 2005.
15. Ruben, R.D., "Quality in Higher Education," Transaction Publishers, 1995.
14. Aft, L.S., "Fundamentals of Industrial Quality Control," Addison-Wesley, 1986.
15. Angus, R.B., Gundersen, N.A., "Planning, Performing, and Controlling Projects: Principles and Applications," Prentice Hall, 1997.
16. "CQI 101: A First Reader for Higher Education," AAHE Publication, 1994.
17. "Process Improvement Reference Guide," Ford Motor Company, 1993.
18. Brassard, M., Ritter, D., "The Memory Jogger II: A Pocket Guide of Tools for Continuous Improvement & Effective Planning," GOAL/QPC, 1994.
19. "Partners in Quality Manual," Ford/WSU Continuous Quality Improvement Symposium, 1995.
20. Roberts, H.V., "Academic Initiatives in Total Quality for Higher Education," ASQC Quality Press, 1995.
21. Miles, L.D., "Techniques of Value Analysis and Engineering," McGraw-Hill, 1972.
22. "Quality Improvement Training Manual," The Paul Hertz Group, Miami, FL, 1989.

23. "Guide to Process Improvement," The Paul Hertz Group, Miami, FL, 1990.
24. "Understanding Prints and Requirements," ACQP Guide, UAW/GM/Delphi Quality Network, 2004.
25. "ASME Y14.5M-1994," ASME, 1994.
26. "Quality System Requirements QS-9000," Automotive Industry Action Group (AIAG), Southfield, 1998.
27. Krulikowski, A., "Fundamentals of Geometric Dimensioning and Tolerancing, Delmar Publishers, 1997.
28. Deming, W.E., "Out of the Crisis," MIT Press, Cambridge, 1990.
29. "Technical Specification ISO/TS 16949," ISO/International Automotive Task Force (IATF), ISO, Geneva, Switzerland, 2002.
30. Oberg, E., Jones, F.D., "Machinery Handbook," Industrial Press, New York, 2000.
31. Shigley, J.E., Mischke, C.R., "Standard Handbook of Machine Design," McGraw-Hill, 1986.
32. Wortman, B., "CQE Primer," Quality Council of Indiana, West Terre Haute, IN, 2000.

**Table 1. Course Agenda and Topics**

<b>Day 1 Agenda</b>			
<b>08:00 AM</b>	<b>Introductions</b>		
<b>08:15 AM</b>	<b>Module 1</b>	<b>Print Reading Overview</b>	<b>L 1-6, S</b>
<b>09:30 AM</b>	<b>Module 2</b>	<b>Shapes &amp; Views</b>	<b>L 1</b>
<b>09:40 AM</b>	<b>Break</b>		
<b>09:50 AM</b>	<b>Module 2 (concl)</b>		<b>L 2, S</b>
<b>10:30 AM</b>	<b>Module 3</b>	<b>Sectional Views</b>	<b>L 1-2, S</b>
<b>11:30 AM</b>	<b>Lunch</b>		
<b>12:30 PM</b>	<b>Applications Exercise 1</b>		
<b>12:50 PM</b>	<b>Module 4</b>	<b>Dimensions</b>	<b>L 1-4, S</b>
<b>01:50 PM</b>	<b>Module 5</b>	<b>Tolerances</b>	<b>L 1-3</b>
<b>02:20 PM</b>	<b>Break</b>		
<b>02:30 PM</b>	<b>Module 5 (concl)</b>		<b>L 3ex-4,S</b>
<b>03:00 PM</b>	<b>Applications Exercise 2</b>		
<b>03:30 PM</b>	<b>Module 6</b>	<b>Holes &amp; Threads</b>	<b>L 1-4</b>
<b>04:20 PM</b>	<b>Wrap up</b>		
<b>04:30 PM</b>	<b>Adjourn</b>		
<b>Day 2 Agenda</b>			
<b>08:00 AM</b>	<b>Review/Agenda</b>		
<b>08:10 AM</b>	<b>Module 6 (Concl)</b>		<b>L 4ex, S</b>
<b>08:30 AM</b>	<b>Module 7</b>	<b>Surface Texture</b>	<b>L 1-3, S</b>
<b>09:20 AM</b>	<b>Applications Exercise 3</b>		
<b>09:40 AM</b>	<b>Break</b>		
<b>09:50 AM</b>	<b>Applications Exercise 3 (cont)</b>		
<b>10:00 AM</b>	<b>Module 8</b>	<b>GD&amp;T Fundamentals</b>	<b>L 1-2</b>
<b>10:30 AM</b>	<b>Applications Exercise 4</b>		
<b>11:00 AM</b>	<b>Module 9</b>	<b>Applying &amp; Interpreting GD&amp;T</b>	<b>L 1</b>
<b>11:30 AM</b>	<b>Lunch</b>		
<b>12:30 PM</b>	<b>Module 9 (Cont)</b>		<b>L 2-4</b>
<b>01:40 PM</b>	<b>Applications Exercise 5</b>		
<b>02:10 PM</b>	<b>Module 9 (Cont)</b>		<b>L 5</b>
<b>02:30 PM</b>	<b>Break</b>		
<b>02:40 PM</b>	<b>Module 9 (Cont)</b>		<b>L 5ex-7,S</b>
<b>03:45 PM</b>	<b>Applications Exercise 6</b>		
<b>04:15 PM</b>	<b>Wrap up</b>		
<b>04:30 PM</b>	<b>Adjourn</b>		
<b>Day 3 Agenda</b>			
<b>08:00 AM</b>	<b>Review/Agenda</b>		
<b>08:10 AM</b>	<b>Module 10</b>	<b>Print ID &amp; General Specifications</b>	<b>L 1-3,S</b>
<b>09:40 AM</b>	<b>Break</b>		
<b>09:50 AM</b>	<b>Course Summary</b>		
<b>10:30 AM</b>	<b>Course Exam</b>		
<b>04:30 PM</b>	<b>Good Bye</b>		

**Table 2. Student Input on Course, Faculty, and Program**

	Sept 04	Nov 04	June 05	Oct 05
Number of Participants	16	17	10	7
<b>A. Subject Matter</b>				
1. How well were the objectives of the course stated?	3.13	3.12	3.50	3.29
2. How well were the course materials organized?	2.69	3.00	3.50	2.86
3. How well were useful examples/exercises used?	2.69	3.06	3.56	2.57
4. How well were the objectives of the course met?	2.63	2.88	3.50	3.00
<b>Subject Matter Mean Score</b>	<b>2.78</b>	<b>3.01</b>	<b>3.51</b>	<b>2.93</b>
<b>B. Instructor</b>				
5. How well did the instructor explain the material?	3.19	3.06	3.60	3.29
6. How effectively did the instructor answer questions?	3.31	3.12	3.60	3.71
7. How well did the instructor encourage participation and discussion?	3.69	3.59	3.60	4.00
<b>Instructor Mean Score</b>	<b>3.40</b>	<b>3.25</b>	<b>3.60</b>	<b>3.67</b>
<b>C. Program Impact</b>				
8. How would you rate the overall program as an educational experience?	2.31	2.53	3.10	3.00
9. How well will you be able to apply what you learned in your work?	1.50	1.94	3.22	1.71
10. How useful is the information to you?	2.38	2.18	3.33	1.86
<b>Program Impact Mean Score</b>	<b>2.06</b>	<b>2.22</b>	<b>3.22</b>	<b>2.19</b>
<b>D. Some Comments:</b>				
<b>11. The best part of the course was:</b>				
a. Learning about this subject was interesting. I wish I had more time to better understand and absorb the concepts.				
b. New knowledge.				
c. Book serves as good reference material. Instructor tried very hard to present, teach, and engage the class. New material covered.				
d. Instructor has extremely good understanding of material covered.				
e. A lot of information imparted to students.				
f. GD&T – as hard as it was.				
g. Really enjoyed learning the “how” to read prints.				
h. Learning about GD&T and brushing up on blueprint skills.				
I. Exercises with actual prints.				
j. Explanation of details regarding the course material.				
k. Class participation was very useful. Helped in understanding info in manual.				

**12. The course could be improved by:**

- a. More time allotted. (3 responses)
- b. Making it span three days.
- c. Working on material.
- d. Fixing errors on examples.
- e. Book needs revision – lots of wrong examples.
- f. More time spent on review, stress most important points, leave morning refreshments in room with lunch, split tests into 2 20 question tests.
- g. Hands-on activities, reduction of amount of info covered – too much to learn and remember.
- h. Separating the GD & T chapters out to a day by themselves.
- I. Reference equipment discussed should be available to demonstrate in class. Application theory.
- j. Need to fix some problems with the material. Most of it was well done, but problems in some cases threw the class off.
- k. Course questions aligned with questions on the test.
- l. Re-write the book – many errors, many ambiguities, bad prints, also faster pace.

**13. How will you apply this course to your work responsibilities?**

- a. Any way I can.
- b. A part of QN staff, I now have experienced the class and can relate to others who have taken/plan on taking.
- c. Understanding and ability to better read and identify points.
- d. In problem solving, an understanding, in general.
- e. I tried but could not find an application.
- f. Help problem solve quality problems.
- g. Will dig deeper on quality issues from a part perspective – fit and function.
- h. Won't use at all

**14. Comments:**

- a. There is a lot of information that is given to retain in 2½ days. A suggestion: have 2 tests, halfway through the course have one.
- b. The information in the course was poorly put together. Program needs re-examining. Update information.
- c. A lot of information to learn in a short time.
- d. Mulchand is a gentleman and a scholar.
- e. A very good course – but I don't see the relativity of this course with my job.
- f. Through interactive discussions and observations with other employees