Teaching Time Standards in a Practical Way: How ET Students Were Taught the Importance of Time Standards in the Real World

Mr. Rajesh Balasubramanian, The University of Memphis

Completed 4 year diploma in Tool and Die making, BS in Engineering Technology, MS in Engineering Technology and MS in Engineering Management. Six Sigma Black belt certified. Worked in the industry for 27 years across India, Singapore and US. Taught adjunct for 8 plus years, currently an Assistant professor at the University of Memphis for last 3 years.

Teaching Time standards in a practical way

Rajesh Balasubramanian
University of Memphis

Abstract

Standardization is all around us - traffic lights, weights, and measures to name a couple. However, Time standards[1] offer challenges in many ways. There are Time standards that Industrial/Manufacturing engineers must establish for production workers/operators. Given the many factors that need to be considered, this paper explores a holistic way of teaching students to appreciate, experience and develop skills to execute Time standard studies in an effective manner. The text around Time standards is limited and theoretical but the hands-on simulators truly drive the point across. The simulators also present an opportunity to understand the challenges to creating Time standards which are discussed within each of the simulation summaries. A lot of what is discussed here comes from proven industrial practices and intended to develop student's ability to get acquainted to real life. The intent of this paper is to emphasize the importance of use of simulators to teach time standards, as compared to just a lecture or use of theoretical case studies.

Having used in the industry, real life examples were introduced into the classroom to teach the challenges associated with the setting of standards. Three distinct types of simulators were run by the students for them to understand the importance of details and structure - Mailing campaign, Car parking and Robotic simulation. The feedback from the students was positive. They expressed how they understood the importance of planning and preparation. The other key feedback received was " it was not as easy as we thought"- which was one of the key objectives of employing the simulators.

Keywords

ET, Time Standards, Time & Motion, Work design, Standardization, Lean Engineering, Simulation, (Eliminate, Combine, Rearrange, Redesign- ECRR), Work Systems

Introduction

In the business world there is a quite common saying , "Time is money"[2]. This is an important business aspect to bring into the classroom. Engineering technology (ET) is that field of applied sciences where knowledge is applied with a specific purpose/outcome. Time and Motion studies is one such course that helps lay foundation to the ET students about the importance of Time standard as well as the practical use of it, in the industry. At the University of Memphis, this course is taught as a part of the Engineering Technology major for both Undergraduate and Graduate degrees.

"Work design and measurement sometimes referred to as "Methods Engineering," is the systematic procedure for subjecting all direct and indirect operations in a manufacturing or

service industry to scrutiny."[3] It includes introduction of improvements resulting in making work easier to perform and allowing work to be done in less time and to improve workflow. In other words, the Methods engineers increase productivity and throughput, reduce process cycle time, and lower the costs of operations for products or services. To accomplish this task practitioners must have a working knowledge of work design and measurement.

Time studies have been done for many decades. They form the bedrock for many project proposals where effort estimation become the basis. All production-based industries use Time standards as their platform to measure productivity. Software companies, Call centers, TSA etc., establish their people and resources using Time standards. They could be historical or current. Time studies in the industrial world have been done from around the 1930s. Frank and Lillian Gilbreths are known to be the pioneers of "one best way to complete a task" [2]. Frederick Taylor started the scientific management where his mantra was "a fair day's pay for a fair day's work" [3.]

This paper presents, how I taught the real-life applications of time and motion studies using the textbook as a theoretical platform. There are various aspects of the teaching methodology that come from my work experiences. I had myself taken this course in this department in 2006 as a part of my MSET degree. It helped lay the foundation for me to understand the fundamentals of Production planning and Workspace design that revolved around the Human element. While it may seem that, this field of applied science is very practical and mathematical, it has the human effort aspect which makes it particularly challenging. I realized this in my very first job. My management would push for increased productivity while the Operations team would ask for increased time for production. This was particularly challenging and difficult to balance. Both sides of the equation seemed correct from their point of view, but my role was to find the "ideal breakeven point." This experience gave me a deeper understanding that I brought to my classroom.

Course expectations

Upon completion of the Time and Motion study course, students are expected to:

- Effectively apply the principles of time and motion study, and concepts of Lean, ergonomics, and industrial safety. Successful completion requires a familiarity with terminology, tools and techniques that are in use globally.
- Demonstrate a working knowledge of Stopwatch Time Study, Worker Rating (Leveling), Predetermined Time Standards, Standard Data and Work Sampling.
- Exhibit familiarity with current periodicals and sources of information pertaining to Work Design, Measurement and Improvement, thorough review, and critique of journal articles.
- Demonstrate the capability to use MS Excel, as well as other tools and techniques useful for quantitative analysis and presentation of findings.
- Ability to decipher the problems, critically think and analyze the problem, creative problem solving and present it effectively.

Student educational backgrounds

The students who attend this course are a blend of traditional and non-traditional students. Traditional students comprise of those who wanted to get a degree in Engineering Technology as their career goal. Another set of traditional students are those, who first chose Engineering Sciences or other majors and decided to move into a more hands-on learning. Most of the non-traditional students are working professionals who want to get a degree to enhance their careers or use employer tuition contribution to grow within their organization. This blend of traditional and non- traditional students changes between day and night classes.

As seen above, the skills levels of my students significantly vary. Engineering Technology applicants need to self-report their ACT scores and are expected to have good proficiency in high school algebra and fundamental trigonometry. Many transfer students have their foundation courses completed but have not decided their field of study yet. Devising an effective teaching methodology to accommodate all the above students is a challenge by itself. Given the common factor that all the ET students prefer hands-on learning the simulators were a useful tool to use for this course.

Need for change?

Before I started to teach this course, I got with the professor who had taught this course for more than 25 years. He gave me great insights about the student base, the way he taught this course and what he envisioned I could bring to this course. This course used the textbook as the foundation, some class exercises, and online resources as a support. The evaluation of the grades was based on quizzes, exams, assignments, and research papers. There were some semesters where the instructor would facilitate a facility tour to enhance student learning. This was quite effective in establishing the fundamentals and the concepts that were needed to complete the course. When I started this course the first semester, I taught it 100% online due to the Covid pandemic. There were many challenges, especially missing the in-person aspects teaching. This course needed some creative thinking to ensure students get more practical hands-on experience to get the concepts correctly. I introduced a car parking and unparking activity which was partially successful. Once we transitioned to in-person learning, I was able to see the challenges faced by the students in learning this course and had to amend ways to achieve the following objectives.

- Understanding the business value of this course
- Students should use the textbook as a theoretical guide and then the classroom lectures were aimed at discussing the concepts.
- Learning had to happen beyond the textbook – reference books, case studies, real life experiences had to be integrated.
- Learning to be resourceful – looking for avenues to solve problems.
- Structured problem solving. Understanding and acknowledging that calculator and MS Excel were only tools and not solution providers.
- To emphasize the importance of effective communication and presentation of their research or project work.

Implementing changes in my teaching.

The first change I implemented in my course was explaining the "Why" to the class. Many of the courses I learnt usually taught me the "How" and the details of it but somehow, they were not presenting the big picture. I take the class through the fundamentals of business – Mission/Vision, Strategic, Tactical and Operational layers of the company. Then they are introduced to the concept of value and its importance in the business and service world. We spend a class on this part because, it lays the foundation for the rest of the course. I share the general nature of their job in the industry. We also discuss the quantification and its relevance to the business world.

The second fundamental change introduced was using the textbook as a tool to understand the concept and not for memorization. Quizzes and assignments were originally based around the problems in the textbook. Grades were assigned solely based on the ability to demonstrate theoretical learning. In my class we used the textbook to discuss the concept but then took real life case studies to discuss about it and seek solutions. For example there is a concept called Single Minute Exchange of Dies (SMED) concept in the Automotive industry. This concept is attributed to Toyota Production System where production lines were quickly able to change to different models of car production, based on demand. Recently there was an article on BBC about how airlines spend a lot on airport fees, due to the time, planes stay at the airport. The changeover of passengers is a small percentage of this time but all other activities such as refueling, clearing trash, loading food etc., took the bulk of the time. We discussed how we could apply the SMED concept to solve the airline issue. Students were divided into groups to discuss and present solutions. This helped apply the concept as well as students learnt collaboration and presentation skills.

The third change introduced was using simulators as an effective tool to translate the text knowledge to hands on activity to learn concepts better. I have been a part of many simulation exercises in my career, and I found them to be especially useful, practical, and more importantly effective. Many improvements project presentation that I have attended did not take off because they very just PowerPoint presentations with a bunch of graphics and data. Making big decision involves building a level of trust and this is what leaders and managers expect. They want to understand the risks as much as they see the rewards. In simulators, they participate hands on and witness the output for themselves. The risk of failure is significantly mitigated, as compared to deciding from a presentation. From the person presenting the proposal, simulators make their lives easy. They do not have to use a lot of jargons and present analysis. Instead, the simulator becomes their voice. This is a win-win situation. I designed and built simple simulators at my job for the very same reasons. These simulators came from my work experiences and projects. These simulators covered technical learning and business aspects in them. Simulators were also designed to represent real life cases. This paper lays out the three types of simulators used in this course to teach students the importance of structured solution development.

The primary intent of these simulators was to understand what challenges lie in completing Time studies successfully and how the importance of understanding preparation, planning and risk mitigation. All students were provided with the standard time study template from the textbook, a clipboard, and a digital stopwatch. All studies were preceded by in class discussions with elemental breakdown filled in the below shown Time standard sheet.

FRED MEYERS & ASSOCIATES	TIME STUDY WORKSHEET	SNAP BACK / CONTINUOUS
OPERATION DESCRIPTION		
PART NUMBER	OPERATION NO.	DRAWING NO.
MACHINE NAME	MACHINE NUMBER	FEEDS & SPEEDS
OPERATOR NAME	MONTHS ON JOB	DEPARTMENT
TOOL NUMBER	MACHINE CYCLE	NOTES:
QUALITY OK?	SAFETY CHECKED?	SETUP PROPER?
PART DESCRIPTION:	MATERIAL SPECIFICATIONS:	TIME

ELEMENT #	ELEMENT DESCRIPTION		READINGS 1	2	3	4	5	6	7	8	9	10	TOTAL / CYCLES	AVERAGE TIME	% R	NORMAL TIME	FREQUENCY	UNIT NORMAL TIME	RANGE	R/X	HIGHEST
		R																			
		E																			
		R																			
		E																			
		R																			
		E																			
		R																			
		E																			
		R																			
		E																			
		R																			
		E																			
		R																			
		E																			
		R																			
		E																			

FOREIGN ELEMENTS:	NOTES:	R / X		# CYCLES	
			0.1	2	TOTAL NORMAL MIN.
			0.2	7	ALLOWANCE + _ _ _ _ _ _ %
			0.3	15	STANDARD MINUTES
			0.4	27	HOURS PER UNIT
			0.5	42	UNITS PER HOUR
ENGINEER:	DATE:		0.6	61	
			0.7	83	ON BACK
			0.8	108	
APPROVED BY:	DATE:		0.9	138	WORK STATION LAYOUT
			1.0	169	PRODUCT SKETCH

Simulator #1 : Using Mail campaign for Service industry.

The Mailing campaign was designed specifically to emphasize the understanding that standards are developed and used extensively in the service industry as well. Many students are of the opinion that Quality, Lean, Time Studies are applicable only to the Manufacturing industries. My previous employer was in the AgTech industry where I used the Time standard methods to help them optimize their Agronomist headcount on the ground.

For this simulator, I made our department administrator the customer and she came to the class and explained the campaign and its requirements. The campaign revolved around raising funds for the department where donors and alumni were to be reached using mails. There were groups of six students in each team for this exercise.

The steps were simple.

1. They had to take a blank envelope.
2. Write the addresses of the sender and receiver as per US Postal standards.
3. Write a letter seeking donations in a professional manner.
4. Fold the sheet as a trifold in a professional manner.
5. Seal the envelope and fix a stamp at the top right-hand corner.

6. Quality inspection

Quality requirements were – Address format, legibility, and professional work. The cost of material and equipment was about $3.00 per envelope, Labor rate was assigned at $16.00 per hour, a good envelope was valued at $200 potential donation, a defective envelope meant lost donation plus lost labor time and cost of rework and material. This simulation was done over three iterations with each iteration having a stepped improvement from the previous one. After each iteration, the metrics used was :

- Number of envelopes made.
- Number of defects during first pass
- Number of people employed.
- Number of rework mails
- Number of Scrap mails
- Potential funds raised/lost.

The first iteration was using a batch of ten envelopes at every process step, with no Time standards and the goal was to produce as many as possible – quality was inspected out. We created a layout in the classroom where we had a Supply person and then an Operations team followed by a Shipper. Quality team operated independently. No directions were provided to the team, they had to rush and make as many as possible. As expected, this was total chaos. After this run, the team gathered and did their numbers. Customer feedback was provided, to the teams.

The second iteration involved brainstorming and making improvements, using lean concepts - Eliminate, Combine or Rearrange. The teams got together and created a layout design, conducted Time studies for each operation, established workspace standards and more importantly did some critical thinking to see how they can move from chaos to a more streamlined production. This was their first big step towards applying the concepts from the book and experiencing the benefits. The teams ran this iteration and saw significant improvements, more importantly they understood the importance of proper planning. There was a big jump in the output with less effort from the team. Customer appreciation was provided accordingly while setting higher expectations.

The third iteration was to get to optimize the overall operations with minimum cost and maximum output by implementing error proofing and Redesign of the product (this is fourth of the lean concept - (Eliminate, Combine, Rearrange, Redesign - ECRR). The students again brainstormed and produced some solutions. They also looked for the most economical options, rather than implementing all their ideas. All ideas were discussed, prioritized, finalized, and then planned. They rearranged the responsibilities, created Work Instructions, Visual Aids, established a production tracker. This helped them reinforce the importance of staying disciplined and repeating the critical thinking process. After this iteration, the results were exceptional. They all celebrated their success, and their customer was obviously there to commend them on this success. Their mailing campaign that was struggling to breakeven in the beginning was producing impressive results with minimum efforts. The most important thing was, they turned it around using structured problem solving. They did this by increasing the Value-added time and minimizing the non-value-added time – again two other Lean engineering terms. Their Time standard after the final iteration

was so much better than when they started. They used less resources, less space and the customer was happy.

The industry has a term called Cost of Doing Nothing (CODN). This means keep pushing people harder and harder without wanting to get to the root cause(s) or even after knowing the root cause(s) not willing to make the change because it is a new way and has not been done before. I teach this aspect as a part of the simulator because sometimes, being a change agent, I have been questioned – What if we accepted the status quo and did nothing. I used some of the experiences of non-traditional students here. We did not just discuss the technical aspects of it, we also discussed communication, challenges and how to overcome them. For example I had a student who took the learnings from my class and identified a significant cost savings opportunity at his job, but his supervisor was unwilling to buy-into the idea. So we discussed the concept of Cost of Doing Nothing (CODN) and how quantification would help break the barrier. Within a few weeks, the supervisor accepted, and the student was able to start his project successfully. This proved to be a big hit with the class about how the classroom learnings could be translated into real actions.

Simulator Results summary

Iteration# & summary	# Envelopes produced	# Defects first pass	# People employed	# Reworked mails	# Scrap mails	Funds raised/(lost)
1. No planning & ten envelopes per batch	40	25	9	25	20	($1,347.00)
2. Implemented Eliminate, Combine & Rearrange & Time Standards set	60	5	6	3	3	$9,843.00
3. Redesign of Cover letter implemented & all processes optimized	80	0	4	0	0	$15,248.00

Each iteration was 24 minutes long : 3 minutes = 1 hour : 8 hours = 1 shift/day

Simulator #2 : Production line concept using Car parking activity.

The Car parking simulator was designed specifically to emphasize the understanding that standards are developed and used extensively in the Material handling industry as well. Car parking simulator was to simulate a test driver who evaluated cars coming off the production line. Memphis has a lot of Logistics industries and many of my students work in the areas of increasing worker efficiency. This simulator was design around this. Another very closely related objective for this simulator was to understand the challenges of studying a process closely where there is a human and a mobile machine interaction. The class was noticeably confident of getting this activity done

quickly and the goal was for all of them to get around the same Time standard. The Time standard was used as the basis to decide the cost of quality per test drive and measure the productivity of the Car jockey. There were groups of four students in each team and five teams in total, for this exercise.

The steps were simple.

1. Driver picks key from the pocket, opens the car and enters the car.
2. Driver fastens seatbelt, adjusts seats and mirrors.
3. Driver backs out of the parking spot.
4. Driver completes the test drive – fixed distance and time was predetermined.
5. Driver parks the car.
6. Driver stops the car, unbuckles the seatbelt.
7. Driver get out of the car, locks the car, and puts key back in the pocket.

Quality requirements were – Seat belt must be fastened, and mirrors checked every time, cannot cross lines while backing out, and parking must be in the original spot without crossing lines and deep enough not to bump into the curb. The only measure of success here was, count of correct parking as compared to the total. This was a night class, so we started on a complete outdoor parking spot on the campus. All parking spots were preassigned taking into consideration the safety aspects. I ensured that the drivers understand their responsibilities and the safety requirements. The drivers, in this case were the owners of the cars and I deliberately included a variety of different models.

The first iteration was a challenge by itself because some cars had tinted windows and the people taking the Time standards could not see in. Added to this issue was, the sunset, which was causing a lot of glares. I still insisted on the class to proceed with the Time study. Each car was studied by five members independently and the driver had to do ten complete cycles. When this was done, each team was to gather back and share their observations. I was walking around from team to team checking their data randomly. All the students quickly realized, it was not that easy, as they had anticipated. Every single member of the team was getting significantly varied reading. This prompted them to get back with their team, including the driver and set up Work standardization. They collaborated with the driver to develop methods to communicate, established clear line of sight and position themselves in such a way that they can capture all data closely and correctly. Quality was a mess with a lot of back out and parking adjustments.

The second iteration went significantly better. The drivers rolled their windows down, communicated the start and stop verbally, cycle start and stop triggers were established. Visual aids helped minimize quality errors. The data from this iteration was particularly good and the results were much better. In fact, the teams were close to each other in terms of Time standard. The students learnt a lot about real life challenges and expressed how much they had learned from this simple activity.

We went back to the class and then the class did a round of ECRR brainstorming to produce a documented process. They created Standard Operating Process, Layout Drawing, Work Instructions as a part of their assignment completion. Many students appreciated this activity and

a few even took this to their work and implemented some aspects of it. The felt they had learned a lot about the importance of observation and planning.

Simulator #3 : Human-machine interaction using robots.

The Robot simulation was designed keeping in mind the modernization of the industry. Today's industry has embraced automation in a big way. What was just powered conveyors a few decades ago has given way to Automated guided vehicles with robots rapidly revolutionizing the industry. Today's industry is adopting robots and automation at a rapid phase and in all areas – Operations, Material handling and Logistics. This simulator was designed with multiple objectives – understanding the importance of Work standardization including Space planning, Operator training and challenges of setting Time standards in a highly automated industry. Memphis being the hub for FedEx and Amazon and a lot of other Logistics companies, this simulator was necessary. We have a Robotics lab in our department where Robotics and Automation is a field of study that, many students take. I partnered with the professor of the Robotics course for this simulator design and execution. Working around and with robots can be particularly challenging given the proximity alarms set on them for safety. This class had to establish a Time standard for a full operation of ten cylinders to be picked by the robot and placed in a specified location, create a layout design and standardized work. Each group had four students and there were five teams in total. The key was the entire class had to arrive at the same Time standard. I created a centralized raw material and finished goods location.

The steps were simple.

1. Operator picks ten raw material cylinders in a tray from the store.
2. Operator walks to the robot's designated location and places them individually.
3. Operator runs the robot.
4. Operator picks the finished goods from the specified location in a tray.
5. Operator drops the finished goods in the inventory location.

There was no quality requirements, as the robots were programmed, and the operation was evaluated multiple times. The only measure of success here was completion of full cycles within an allotted time. All students had to run five cycles each and each time had to compile their time standards.

The first iteration started off with chaos. By design, the robots were placed near each other. This meant that they would stop as and when someone or something came into the safety space. They was meant for an operator to stand and operate individually. With the students fetching their trays from a centralized location, they were stopping other team robots often. All teams encountered a lot of delays due to the timing of their runs.

After this iteration, the teams came together and did brainstorming and spend time establishing the robot safety boundary. They made a sketch and established them on the floor. This gave them the opportunity to share the safe walking spaces with the other teams. They also moved their raw material and finished good locations close to their robots using the lean concept (Point of Use-

PoU) and ECRR. They also discussed the option to move the robots into a very standard arrangement working with the Robotics professor. This change was not made as the robots were used for his other classes. All discussed adjustments were made before the start of the next iteration.

The second iteration went a lot smoother. The cycles went very well and the readings from the teams and the overall class was very consistent. I then challenged the teams to see if there was a possibility to increase the operator to robot ratio meaning can an operator run more than one robot. I knew this was possible beforehand. The class did the number and they all agreed that was possible. Through this simulator activity, the students had learnt the challenges of automation and how redesigning the workspace and operations can significantly improve productivity without compromising on quality or safety. This can also improve productive and help set very practical goals.

As a standard practice, we went back to the classroom and then the class did a round of ECRR brainstorming to produce a documented process. They created, Layout Drawing, Work Instructions as a part of their assignment process. All the students appreciated the hands-on experience from this activity and more importantly realized that improvements are also possible in automation industries.

The three simulators were designed keeping specific learnings that I wanted the students to take away. They worked very well both from the educational aspect as well as the experiential learning. This approach was necessary for Engineering Technology students, and they would be spending most of their time hands on with the machines and operators. They would also need to know how to propose a solution in a simple yet effective way.

Conclusions and next steps

In conclusion, my goal of taking up teaching as a profession after working in the industry was precisely this: it was to bring pragmatic approach to the classroom where students were not just memorizing to make their grades but were also seeing the other aspects of learning that would make them well equipped for their future jobs. By including the diversity of production and service industry, this course was appealing to those students who thought that Motion and Time study was a Manufacturing only “thing.” By the end of my second semester of teaching this course, quite a few students had already chosen projects in Lean Ops & Strategy and were actively engaging with me on their projects. They were able to get incredibly superior results on their projects and were very motivated.

The changes made to this course were essential as a part of continuous improvement. Most of the improvements were suggestions made by, the previous professor, department chair and industry advisory board members. My past work experiences also helped me bring in some practical solutions to the class. The general feedback I received from students was they found the course very demanding but learnt a lot. They felt uncomfortable presenting in front of the class and answering questions but acknowledged that it was as essential part of their skill development. The

department chair also heard positive feedback about my overall teaching and encouraged me to stay on this path.

To keep the course more current and relevant, I plan to keep the diversified teaching approach. I will also continue to learn from other professors, journal articles and conferences. At this point in time, the impact of my changes are exceedingly difficult to measure and quantify because the student skills sets vary every semester and I try and adapt my teaching methods that best suit the class. This effort will continue to get the students to not only be more prepared academically but also for their future endeavors.

References

1. Mikell P. Groover – Work Systems: And the Methods, Measurement, and Management of Work – April 2006
2. Jyotshana Rani– What is the Time – Equals- Money Concept: https://www.opengrowth.com/resources/what-is-the-time-equals-money-concept – Dec 2022
   Benjamin Franklin – The American Instructor – 1748
   https://en.wikipedia.org/wiki/Time_is_money_(aphorism)
3. Fred E. Meyers and James Robert Stewart- Motion and Time Study for Lean Manufacturing, 2001, Page# twenty-nine
4. Scientific Management Theory https://courses.lumenlearning.com/wm-introductiontobusiness/chapter/scientific-management-theory/ - Jan 2023

Bibliography

1. Stephen N. Chapman (2006) – The fundamentals of production planning and control
2. Shigeo Shingo (2007) – Kaizen and the art of creative thinking
3. Kiemele, Murrow & Pollock (2007) – Knowledge based management: A systematic approach to enhanced business performance and structured innovation.
4. Bob Boylan (2005) – Get everyone in your boat rowing in the same direction: five leadership principles to follow so others will follow you.
5. Eliyahu Goldratt et all (2012) – The Goal : A process of Ongoing Improvement
6. James Womack & Daniel T. Jones (2003) – Lean Thinking: Banish Waste and Create Wealth in Your Corporation.
7. Peter M. Senge (2006) – The Fifth Discipline : The Art & Practice of the Learning Organization
8. Kjell B. Zandin (2021) – MOST Work Measurement Systems

About the author

The author is an assistant professor at the Herff college of Engineering at the University of Memphis, teaching Lean Engineering and basic Manufacturing processes courses. Was an adjunct faculty for eight plus years before taking up full time teaching. Has twenty-seven plus years of working experience in Manufacturing, Supply chain and Retail industries worldwide. Has a BS in ET for BITS, India, MS in ET from University of Memphis, MS in Engineering Management from Christian Brothers University. Has a Six Sigma Black belt certification from University of Texas. Secretary of Memphis Joint Engineers Council and ASQ.