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Applying Total Quality Management to the Educational Process*

ROBERT C. WINN
Engineering Systems, Inc., 4775 Centennial Blvd., Suite 106, Colorado Springs, CO 80919, USA
ROBERT S. GREEN
USAF Directorate of Technical Training, Randolph AFB, TX 78150-4321, USA

Total Quality Management (TQM) is recognized as an important management philosophy and is widely used in US industry. It has been used very successfully in the development and acquisition of systems such as satellites and aircraft to preparing officer performance reports. Over the last few years, TQM has been applied in the education industry. Most of the applications have been in the administrative side of the institutions, but some schools have applied TQM to curriculum development. The Air Force Academy has been a leader in this application of TQM. In this paper, the principles of TQM are described with an emphasis on the importance of identifying the customer and analyzing the processes. The 14 Points of Dr. W. Edwards Deming, which form a framework for the implementation of the TQM, are individually applied to the academic environment based on the experience gained at the Air Force Academy.

INTRODUCTION

TOTAL Quality Management (TQM) was first espoused by Dr. W. Edwards Deming in the late 1950's. His ideas were not accepted by US industry but were heartily endorsed by Japan in their recovery from World War II. Largely as a result of the implementation of TQM, 'Made in Japan' has changed from a derogatory term to high praise [1].

In the 1980's, US industry began to see the value of a TQM approach. Such companies as Motorola and Federal Express have turned failing companies into world leaders. Motorola now does a good deal of business selling to Japan [1]. Universities, however, have been slower to see the value of using TQM in their business, although several schools are now using TQM to improve the administration of the university. In 1990, Oregon State University endorsed TQM as its management philosophy and has experienced outstanding success in improving the operations of the university. For example, using TQM they reduced the average duration of remodeling projects by 23% [2]. In 1988, the Air Force Academy began an attempt at applying TQM to curriculum development and, in 1990, offered a course that was designed and conducted using the principles of TQM.

The course that we chose as the target of our TQM efforts was Energy Systems, a first course in thermodynamics. This course is a core course and is therefore taken by almost all of the cadets at the Academy. Cadets from every major discipline take the course as a graduation requirement, so it differs from traditional thermodynamics courses in that the classes have a large portion of students who are not engineers. Thermodynamics is a difficult subject for technically inclined students and is even more so for students whose interests lie in the humanities or social science. We chose Energy Systems as our target for TQM implementation for two reasons. First, Energy Systems was not a very popular course among the cadets, not unlike thermodynamics courses anywhere else in the country. We felt that if we could improve this course in the eyes of the students, we will have made a significant step. Second, the people charged with running this course, the authors, had been strong advocates of implementing TQM at the Academy from the very beginning.

Several papers have been published which describe just what we did to implement TQM in our course [3–5]. In those papers, we reported impressive improvements in many areas of the course. The students liked the course much more than before and felt they learned more as well. Quantitative measures of student performance increased significantly as well. The purpose of this paper, however, is not to rehash the details of one specific implementation. Rather, it is to make some observations and recommendations based on that experience that can be applied to any university situation. For readers that are interested in the details of our particular implementation, we refer them to the other papers or suggest that they contact the authors directly.

TQM PRINCIPLES

The one factor that is the most influential in the success or failure of a TQM implementation effort

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is universal endorsement, in particular at the top. If management is not completely sold on TQM, it is unlikely that an implementation effort will be successful. Endorsing TQM represents a fundamental change in the way one does business. Less than full support by anyone in the chain of authority essentially condemns the effort to failure.

In our case at the Air Force Academy, we had the support of everyone above us in the chain of command, from our department head, through the dean, all the way to the Secretary of Defense. That is not to say that there were no opponents on the faculty. Faculty members are a very independent group of people, and consensus on any issue is unlikely. Because those who opposed TQM implementation were not in our chain of command, they did not prevent us from implementing TQM; however, if one of the opponents happened to be in our chain of command, we would have had a much more difficult time.

It was also very important to get the endorsement of the students as well as those up the chain. To earn the student's endorsement, we had to make them part of the solution. TQM is a participative management philosophy, and the students had to participate throughout the effort. We therefore had to teach them about TQM and then show them how we were changing things in the course. Without that education process, we would not have had the support of the students that we enjoyed.

Once the commitment is made to implement TQM, one of the first steps is to identify the 'customers' or stakeholders. To do this, you must treat the educational process as a system; all elements and the interactions between those elements must be addressed. Process improvement should begin and end with the customer [6].

A systems approach to industrial process improvement is relatively common now. In an industrial application, the customers will include the purchaser of the product or service, suppliers, subcontractors, etc. A careful identification of the customers in the university setting needs to be accomplished. It can rightly be argued that there are many customers of the university including the students, the employers of the school's graduates, the parents of the students, the taxpayers, the whole of society, the Board of Regents, the State Legislature, etc. We have found that by identifying our students and the employers of our graduates (the Air Force) as our primary customers, we would end up satisfying all of the other customers. On the other hand, by focusing on a customer that is too far removed from the operation, it is very easy to overlook the needs of the more immediate customers.

It is not uncommon for universities to address the needs of industry in curriculum development; however, students are usually treated more as a product than a customer. It is likely that many of the problems that plague some universities stem from an effort to make a remote body happy while inadvertently ignoring the students. This is a classic case of improperly defining the system. All relevant participants must be included in the educational system. Once all participants are identified, the relative importance of each participant can be established. Taking a systems approach to education can be a very useful endeavor.

If the student is identified as one of your customers, you must try to satisfy that customer, but you must be very sure you know what that customer really wants. An Air Force general may say he wants a fighter that can turn inside a football field at four times the speed of sound, but he really does not want that—even if it was technologically possible, he couldn't afford it, Customers must make an informed decision in deciding what they want, taking into account costs, performance needed, legal issues, etc. Students may say they want an easy 'A' in every class, but what they really want is an education. If high grades were passed out with no learning taking place, prospective employers would quickly learn to avoid hiring the graduates of that university. The perspective we should take is that the students are, at least in principle, paying for the services we provide. We must be sure that we are satisfying their real long-term needs, not simply short-term desires.

DEMING'S 14 POINTS

The 14 points of Dr. W. Edwards Deming form a framework for the implementation of TQM [1]. We have used this list as a checklist of sorts in our effort. These 14 points are general enough that an implementation at one school would probably look considerably different from one at another school. The way that these 14 points should be used is to come to a consensus as to the application of each point to the particular situation at hand.

In the following paragraphs, we will present some suggestions on how each point might be applied to the university setting in the administration of the university and in the curriculum. Realize that these are just suggestions, many of which will be totally inappropriate at a particular university. Our purpose here is to give some food for thought and suggest by comparison a methodology one could use to apply TQM to a unique situation.

1. Create constancy of purpose

Develop a mission statement as your corporate purpose or aim. For example, the mission statement for a university might be, 'To develop the skills, attitudes, and motivation in our students so they will become responsible citizens and be capable of making positive contributions to society.' The mission statement for a college of engineering might be, 'To develop the skills, attitudes, and motivation in our students so they will perform in a technically competent, socially

responsible, and ethical manner as engineers entrusted with the safety and comfort of their clients.' Developing a mission statement is not a trivial task; it requires a real understanding of just why the organization exists. The mission statement is also hierarchical; the department's mission depends on the college's mission, which depends on the University's mission, and so on. Once the mission statement is developed, *everyone* (not just the faculty and administration, but everyone employed by the University) must know how they contribute to the mission. The analysis suggested here is to assess the value added by a process. If a process or a position does not add value, that is, does not contribute to the mission, it should be eliminated.

2. Adopt a new philosophy

Insist on quality in everything—classroom instruction, bookstore service, campus policing, restroom cleaning, interactions with the legislature—everything. To achieve this quality, an atmosphere of cooperation as opposed to competition must be instilled. This is particularly true in the classroom; management must ensure that the processes put in force encourage cooperation at every levelstudent to student and faculty to student. Do away with the 'us versus them' attitude. Instead ask questions like, 'What can we, the faculty and staff, do to make the learning experience in this classroom better?' or 'What can we, the teacher and the students, do to ensure every student has the best opportunity to learn this material?' It is a completely different approach than most of us experienced in school as students.

3. Cease dependence on mass inspection

Focus on the product or service process. Don't depend on audits, tests, or inspections to build quality. Inspections will only keep bad products from hitting the market, but there are large costs incurred with each bad piece. The analogy in education is that the failed student is scrap that must be either reworked (take the course again or get extra tutoring) or discarded. We need to develop processes in which there is less testing but more focus on progress in learning. For example, ask yourself why you are giving a particular test. If the answer is to evaluate your students, then ask yourself if you need this extra piece of evaluative information. There is evidence that we test far more than is needed to evaluate our students [7]. On the administrative side of the university, are there too many checks and balances? Can a process be changed to make inspections unnecessary or at least to reduce the need for inspections? Statistical process control can be an important tool in developing processes that do not require much inspection [8].

4. End the practice of conducting business on cost alone

The lowest bid usually does not result in the lowest life-cycle cost. In all our processes, we need to focus on long-term costs and benefits. That may mean that the trendy new course not be offered if it means the failure of a course with more long-term value. Awarding the printing contract to an off-campus vendor may have lower first cost, but the inability to get adequate turn-around time or poorer quality may make the overall cost of that decision very high. University professors often complain about the poor job the high schools are doing in preparing students for college. The long-term costs of supplying educated people to society may be less if some of the resources of the university were spent on improving high and junior high schools.

5. Constantly improve processes

Are your customers (the students and their future employers) more satisfied than they were last semester? Are the faculty members happier? Are the secretaries happier? Are the suppliers of the University happier? If the answer to a question is no, find out why and fix the situation immediately. If the answer is yes, determine what it was in the process that made it so. In any case, analyze the process to determine what changes can be made to make it better. Incremental improvements must be made every semester. This is essentially the Kaizen philosophy—encourage innovation, but insist upon incremental improvements, especially after the innovation [9]. The phrase, 'if it's not broke, don't fix it,' does not apply. To help decide where to look for things to improve, use course grades, student performance on 'anchor' problems, student critiques, faculty and staff organizational climate surveys, inputs to suggestion boxes, summaries of complaints, etc. Carefully designed questions on anonymous surveys can be very valuable, but talking directly to the customer is still the best way to find out what the barriers are. There is a side benefit to talking directly to the students about their problems—they appreciate it and make the 'us versus them' attitude much less likely.

6. Institute training

Everyone needs to know their job. The faculty is certainly well educated in their disciplines but maybe not in the art of teaching. Faculty development programs help teachers know their jobs. Word processing classes help secretaries do their job better. Money spent on faculty and staff training has long-term payback. In addition, you should teach TQM to everyone—faculty, staff, and especially students. The more everyone knows about the management principles used on a daily basis, the easier it is for everyone to buy into the idea.

7. Institute leadership

Emphasize leadership instead of management. Everyone at the university has a leadership role of some sort. Each person in a supervisory role (including the faculty) should try to be a coach and

teacher, not a judge and overseer. As put by Senge, the leader should be a designer, a creator of an environment [6]. Effective leaders will search for barriers to communication and productivity and remove them. A poorly lit classroom can have a significant effect on student performance. A teacher who is an effective leader will see to it that the lighting problems are fixed. A teacher who will adjust the due date on a project based on special student situations, will probably increase the learning of his students.

8. Drive out fear

In the academic setting, fear is often a big factor in student and faculty performance. For students, any steps that can be taken to reduce the fear involved in taking a test will pay large benefits in student performance and attitude. Allowing for a make-up exam, points for reworking missed problems on an exam, and dropping a low grade are examples of little things that can be done to reduce student fear. Teachers must balance their roles as educators versus evaluators. When asked, most professors will readily say that their job is to educate their students; however, the amount of time they spend on evaluation tends to contradict this view. On the faculty and staff side, fear can also play an important role. If a high price must be paid for failure, few people will be willing to risk experimenting with a promising new innovation, thus keeping a process improvement out of the system. If a teacher would like to try an innovative teaching technique, the effort should be applauded even if it is a failure. Certainly something of value will have come from the experiment. Researchers must have the opportunity to fail without the fear of demotion or lack of promotion opportunity. Fear is a powerful emotion and can have very negative effects on the performance of an organization.

9. Break down barriers

Encourage cooperation, not competition. Encourage the forming of cross-function teams to address problems and process improvements. A team made up of faculty, staff, and students (perhaps from more than one department) will have a broader perspective in addressing issues than a more narrowly composed committee. When addressing a problem in the registration process, address it with a team consisting of representatives from every involved organization—faculty, advisors, students, registrar, computer services, etc. A solution devised by only one organization will usually have a negative impact on some other organizations. Bringing everyone in on the decision process will usually result in a better solution, and certainly one that is easier to accept.

10. Avoid obsession with goals and slogans

Just telling someone to do good is meaningless without the means to achieve that goal. Management must improve the processes so that the goals can be achieved. Stating that 80% is the minimum acceptable score on an exam will not by itself achieve that goal. Stating that goal and then providing excellent instruction, arranging for study teams, giving extra help where needed, etc., will give the students a much better chance for success.

11. Eliminate numerical quotas

It is often said that numbers are the crutches of poor supervision. On the assembly line, this principle is easy to see; in the academic setting, it is not as obvious but just as true. If there are quotas established for 'x' number of papers per year or 'y' number of majors enrolled, quality will decrease. The number one priority should be quality. Only after the process is designed so that quality is assured should the questions of quantity be addressed.

12. Remove barriers to pride of workmanship

Pride is a strong motivator. In the academic setting, pride certainly flows from personal and group achievements, but there is also a good deal of pride in the institution as well. Often this institutional pride is a result of having survived the program, but it can also stem from having had a part in the development of that program. If the students are included in some of the decision-making processes, they will develop a strong pride of ownership that can have a significant impact on their attitudes. A step as simple as talking to student representatives about their concerns can change an antagonistic faculty/student relationship into a cooperative one. Using some of the elements of cooperative learning also empowers the students by sharing some of the teaching role with the faculty. A secretary who is allowed to choose how the work is to be done and has a voice in some of the administrative decisions that affect secretarial work will be a much more productive and happy worker. Barriers between departments and colleges should be dismantled; each professor can learn a lot by studying the operation of another department.

13. Organization-wide involvement

Everyone in the institution must be included in the education process and be aware of and concerned for their immediate 'customer'. Lab technicians who sit in on the courses that they support will have a much better idea of how their work contributes to the mission. Secretaries who learn about new techniques and technologies for use in the office are much more likely to suggest improvements to the processes they are exposed to. Professors should audit courses in other departments, particularly those courses that are prerequisites for their own courses. Faculty members who learn about TQM are much more likely to endorse the concept and to suggest new ways to implement TQM in their jobs. One cannot predict just what

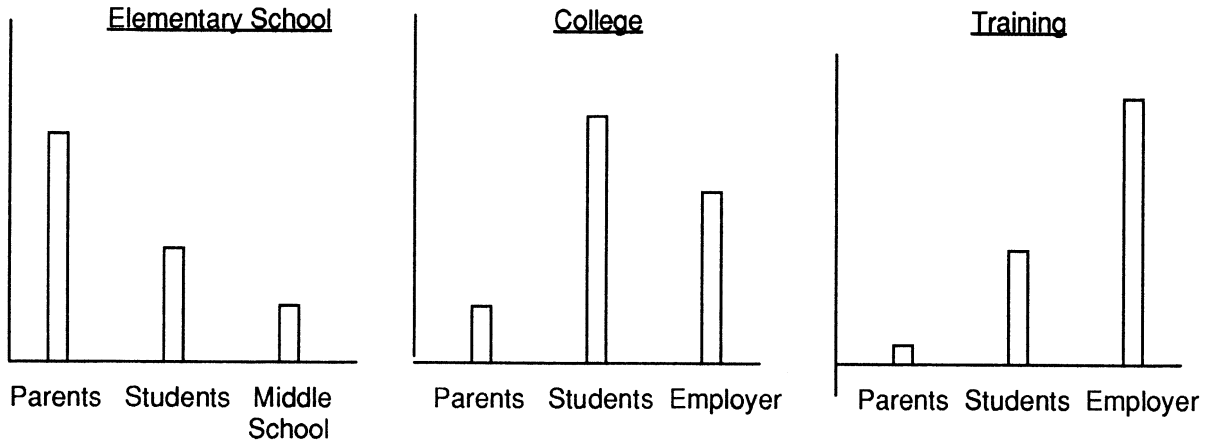

Fig. 1. Relative customer importance.

piece of knowledge will spark the idea that will lead to a significant process improvement.

14. Define management's responsibilities to make it happen

Management, at every level but particularly at the very top, must take and show pride in adopting the TQM philosophy. The meaning of each of the 14 points as related to the mission must be clear to all involved. This is not a trivial process; a good deal of time must be spent in analyzing the various processes and discussing how the 14 points relate to those processes. The time spent in this effort forms the foundation for all of the TQM implementation.

APPLICATION OF THE 14 POINTS

The above 14 points are very general. When TQM is successfully applied, it is a result of a careful study of each point and a clear determination of how each applies to the situation at hand. No two applications of TQM will be the same. The form that a particular implementation takes is dependent on many factors such as the size of the institution, whether the institution is private or public, and the strengths of the people involved, but the most important variables are the maturity of the students and the involvement of the employer. Careful consideration of all aspects of the educational system will help determine just how the TQM implementation will ultimately look.

The principles of TQM can also be applied to high school, middle school, and elementary school educational processes as well as to training situations. The principle differences in the implementation of TQM will be the result of the relative weight assigned to each of the customers at the different levels of education. The weighting that is applied is primarily the result of the maturity of the students, but there are other considerations as well. For example, in elementary schools the most important customers, listed in order of importance, are the parents of the students, the students themselves, and the middle school to which the students are headed. As the maturity of the students increases, the students replace the parents as the most important customer. In a training situation, the most important customer is the organization that needs the individuals trained. Regardless who your primary customer is, it is essential that the students be included in the list of customers. Figure 1 shows a qualitative assessment of the relative importance of various customers in different educational environments. Please keep in mind that only a few of the potential customers have been presented, but students must be considered in each case.

CONCLUSIONS

TQM can be a powerful tool in the educational setting even though it was developed with manufacturing processes in mind. The key elements to a successful implementation are (1) gain the support of everyone in the chain of supervision, (2) identify your customers, (3) focus on refining the process, and (4) use Deming's 14 Points as a guide and checklist during the implementation effort. The final result will be a more efficient operation and a teamwork attitude rather than an 'us versus them' attitude between faculty and students.

REFERENCES

1. M. Walton, *The Deming Management Method*, Perigee Books, New York, NY, 1986.
2. L. E. Coate, *Total Quality Management at Oregon State University*, Oregon State University, Corvallis, OR, March 1992.

3. R. S. Green, R. C. Winn, and M. L. Smith, Integrating Total Quality Management into a thermodynamics course, *Proceedings of the First International Conference on Post High School Technical Education*, Jerusalem/Tel Aviv, Israel, December 1991.
4. R. S. Green, and R. C. Winn, Application of Total Quality Management to engineering education, *Proceedings of the ASEE Annual Conference*, Toledo, OH, July 1992.
5. R. S. Green, and R. C. Winn, Application of Total Quality Management to a thermodynamics course, USAF Academy Technical Report, (accepted for publication).
6. P. Senge, *The Fifth Discipline*, Doubleday, New York, NY, 1990.
7. R. C. Winn, How much testing is enough? *Proceedings of Frontiers in Education '90*, Vienna, Austria, July 1990.
8. G. Bounds, L. Yorks, M. Adams, and G. Ranney, *Beyond Total Quality Management: Toward the Emerging Paradigm*, McGraw-Hill, Inc., New York, NY, 1994.
9. M. Imai, *Kaizen*, McGraw-Hill, New York, NY, 1986.

Robert S. Green is currently attending the Air Command and Staff College. Previously, Maj. Green was a technology analyst studying distance learning at the Air Force's Headquarters Air Education and Training Command. He has also served as an Assistant Professor of Aeronautics in the Department of Aeronautics at the US Air Force Academy and conducted aircraft propulsion research at Wright Aeronautical Laboratory in Dayton OH. Maj. Green received a B.S. in Aeronautical Engineering from the George Washington University. He is a senior member of AIAA.

Robert C. Winn is a Senior Consultant with Engineering Systems, Inc. in Colorado Springs, CO. Prior to retiring from the US Air Force, Dr. Winn was a professor in the Department of Aeronautics at the USAF Academy. He also served as the Chief Scientist of the USAF European Office of Aerospace Research and Development in London, England and was an instructor pilot in several Air Force aircraft. Dr. Winn received a B.S. and M.S. in Mechanical Engineering from the University of Illinois and a Ph.D. in Mechanical Engineering from Colorado State University. He is an associate fellow of the AIAA and a member of the SAE.