

# Deming, Zen and Calculus: Striving for Quality in Teaching Mathematics

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A new and modern approach to teaching Calculus offers a richer and varied approach that caters for different needs and different learning methods. We measure this approach against the Quality principles of Deming and the philosophical Zen view of Quality.

## Introduction

The three bedfellows in the title might at first glance seem to have very little in common. But the astute reader is sure to have guessed that the common factor is Quality. Deming is synonymous with Quality but how Zen and Calculus are drawn into the threesome might not be so apparent at first glance. This paper is mainly about Calculus and how it stands on the shoulders of Deming and Zen to cater for different learning styles and in so doing reach greater heights.

## About quality

Companies throughout the industrial world have adopted the principles of quality management to improve production and products and yet, to define quality is not a simple task. Single aspects of quality are often emphasized such as “fitness of use”, attributed to Joseph Juran [1] one of the prominent names in quality. “Conformance to requirements set by consumers” is the aspect highlighted by Philip Crosby [2], another of the quality Gurus. Kaoru Ishikawa [3], a Japanese quality expert says that a quality product is “most economical, most useful and always satisfactory to the customer”. W. Edwards Deming [4], also referred to as the father of quality, advocates that quality “should be aimed at the needs of the customer, present and future”. Important in all these highlighted features of quality is that the customer decides on what the quality of the product and or service is, not the manufacturer or service provider. In the academic world it is not so easy to know who the customer is. Is it the student? Or is the student only the product delivered to the potential employer who then in turn becomes the customer or are the parents who provide the funding the customers? Is society in general the customer? Perhaps it is all of the above [7].

There are many differences between industry and education. In a manufacturing environment products are lifeless objects whereas in a university we deal with diverse people with diverse abilities. It is far more difficult to control the quality standards of the student input than in the case of raw materials. Entrance requirements, conformance to standards are far more difficult to measure. The interaction between student and lecturer can hardly be compared to an assembly line. It is an interactive process where personalities and attitudes play important roles. Students have different abilities and different talents and learn in different ways. Likewise, the quality of the output in the manufacturing environment is simpler to measure than the quality of a student at the end of his studies. For manufacturing firms profit is an easy indicator for

measuring effectiveness. In education, on the other hand, outcomes such as knowledge, know-how, wisdom, character and preparedness for the job market are more difficult to measure [7]. Can the same quality principles then apply for both a manufacturing and a service industry? More specifically, where does quality fit into teaching Calculus? In order to answer these questions we zoom in on two diverse views of quality and see how these bear on teaching Calculus.

## About Deming

Of quality gurus, it is Deming whose view on quality has most bearing on education. Although education is different from industry there are many similarities as well. Quality is an integral and desirable feature of the products of both industry and education and it is here where our interest lies. Deming emphasizes that attention should be paid to the quality of the system as a whole, that the quality control step may be scaled down. In education this means that over-emphasis of final exams is not desirable. Examining a student on everything he has learned takes up considerable time and comes down to inspecting defects out rather than building quality in. The quality of the teaching system is important rather than the examination.

Deming has drawn up a list of 14 points along which the quality any organisation can be improved. These points apply to small organisations as well as large ones, to manufacturing as well as to the service industry (such as education) [4] and are listed and discussed in a subsequent section.

Before we look at a more philosophical view of Quality that endeavors to link the West and the East, an interesting fact about Deming. Deming provides a seemingly Western outlook on Quality, yet he started his work after the Second World War in America but was not appreciated in his own country. He was subsequently invited to Japan where his work was greatly appreciated. They could apparently better relate to his ideas. It was only in the 1980's that Deming's work took off in America. It does therefore seem as if there is a strong component of Deming's work that links with the Eastern outlook.

## About Zen

Different from the definitions of the Western gurus, is the definition of Quality given by Robert Pirsig in his amazing book, *Zen and the Art of Motorcycle Maintenance* [5]. The book, a true story, is of a father and son travelling by motorcycle through America. The father once had an academic position teaching the subject of *Quality*. During the long hours on the motorcycle his memory flashes back to his struggle to fathom what exactly *Quality* is. He eventually succeeds in formulating his clear understanding of *Quality* and sees that it links up with the Zen philosophy. But the toll for this is high and it drives him to the brink of insanity. The journey with his son is a healing process during which he gets a chance to review and reformulate his ideas on *Quality*.

Pirsig distinguishes between *Romantic Quality* and *Classic Quality*. *Romantic Quality* is the present, the here and now of things, what you immediately like. *Classic Quality* on the other hand is the long-term perspective, the more common-sense side of it.

When producing work he says: "The way to see what looks good and to be at one with this goodness as the work proceeds is to cultivate inner quietness, a peace of mind so that the goodness can shine through." This state of inner quietness is what the Zen Buddhists seek after. This is the state of being one with your work. He talks about a situation where you are stuck with a problem. Pirsig calls it the zero of consciousness and says it isn't the worst of all

possible situations, but the best possible situation to be in. It is exactly this “stuckness” that Zen Buddhists go to so much trouble to induce. Your mind is empty. No matter how hard you try to hang on to it, it is bound to disappear. Your mind will naturally and freely move towards a solution.

It is time to turn to Calculus. What follows can be applied to Mathematics Education in general but because Calculus is a subject common to all universities we focus thereon in particular.

## About Calculus

The modern approach to teaching Calculus is less formal and less technical and there is more emphasis on applying concepts. There seems to be a move towards teaching Calculus in a more student-centered way away from a less lecturer-centered approach. The move is also to diversify the way of teaching in order to utilize different aptitudes and different styles of learning better. The recent reform approach to teaching Calculus has brought many changes, not only regarding the presentation in textbooks but also regarding tuition methods. This approach places less emphasis on rigorous proofs and more on understanding concepts. The student is expected to develop thinking skills, to work more independently, to become proficient in problem solving and to be able to function well within a group. For this purpose worksheets, workbooks and projects have become part of most courses. New also, is the use of technology (graphing calculators or software packages) to illustrate and master concepts.

Has the new way of teaching Calculus any bearing on the Quality of the subject as it is taught and as the students master it? In other words, has the new approach improved quality measured against the Deming philosophy? And where does the Zen view of quality and the Reform approach to Calculus meet?

## Calculus and Deming

We look at each of Deming’s 14 points, each in turn.

- (i) **Create constancy of purpose.** It is imperative that universities keep up with market demands and constantly improve their approach to presenting the subject. A very abstract approach to teaching Calculus can be satisfying to the lecturer and to the few students that aim to make abstract mathematics their future, but for the majority of students need to have a more market orientated approach.
- (ii) **Management must take the leadership for change.** Management in a Mathematics Department ultimately rests with the head of department but every lecturer is a manager as well because he has to take control of the course he teaches. The head of department should take leadership for change but it is not uncommon for the change to be initiated from the lower echelons and infiltrated through the department. The university environment provides the freedom to every lecturer to introduce change and it is the responsibility of the top management to evaluate the changes open-mindedly.
- (iii) **Cease inspection to achieve quality.** The new approach to Calculus, although not totally ceasing inspection, is a move away from emphasizing inspection. A better approach is to calculate an assessment mark from a variety of activities. Worksheets, projects and assignments can form an integral part of the course. Students differ in their abilities and also in their method of work and our teaching approach should cater for this. Not all students perform well under the stressful conditions. Given more relaxed circumstances

and more time the student often cultivates a more long-term understanding of the subject. Although working under pressure could be a useful exercise, it does very little towards learning. The practice of an open-book exam is another product of a more relaxed approach to learning. In this case students make an effort to read the textbook in case they've missed something.

- (iv) **End the practice of awarding business on the basis of price tag.** Teaching Calculus in the reform approach require a mature and creative lecturer. It requires amongst other skills the ability to initiate discussions in class, compile projects from newspaper articles and be in touch with trends in the market place. It also requires of the lecturer to be mature enough to grant students the freedom to develop their own particular way of learning and expressing themselves and not insist on unnecessary uniformity. It is not advisable to have inexperienced staff take on the responsibility of this type of teaching.
- (v) **Improve constantly.** Constant improvement in a modern approach to Calculus has two faces. The first of these is from the management side. A course taught in this fashion requires of the student to do worksheets and projects and papers that are set in a creative, problem-orientated fashion. Most lecturers will find that a process of constant improvement is closer to reality. It is also stifling to repeat the same projects year after year. Change and improvement is the lifeline of many a lecturer. The second face of constant improvement is from the student's side. Two of the areas where most students in a Reform Calculus course experience difficulty are in verbally formulating ideas and visually conceptualizing concepts. These skills are often neglected at secondary school level. Although inept at first students will constantly improve throughout the course.
- (vi) **Institute training on the job.** Training on the job for the lecturer consists of attending workshops, seminars and conferences, all invaluable and essential. Training for students in the new approach means doing away with formal lectures and initiating discussions in class and in tutorial sessions. Students learn throughout the course and not simply before exams, as mentioned before.
- (vii) **Insist on leadership.** It is both the student and the lecturer's right to insist on leadership. Because the new approach to Calculus is more informal the lecturer becomes a facilitator rather than a dictator. Yet the lecturer still sets the pace and conveys the mission and aim of the course. The lecturer plays a valuable part in discussions and answering student queries, also for projects. Although more informal, it is essential that the course is still well organised with speedy assessment of worksheets, projects and exams.
- (viii) **Drive out fear.** Few students can perform well under conditions of fear. Mathematics is unfortunately a subject where fear in students is traditionally not uncommon at all. Fear is debilitating and causes inactivity. A more relaxed approach, assignments and projects as well as open book exams are ways of driving out fear. Students feel more inclined to view their opinions in a less formal class situation.
- (ix) **Break down barriers. Work as a team.** Mathematics is traditionally a lonesome activity and when confronted at first with group work, most students find it a strange concept, yet soon grow to like it and see the benefit. Group work has become an integral part of the modern way of teaching Calculus. It is preferable for the same group to work together throughout the semester. They get to know each other and build a team spirit

as they go along. Every student gets the opportunity to contribute in his unique way. Wording of a problem often clarifies thoughts and lead to a solution. Added benefit is drawn from the idea of group work when dealing with large groups of students. Assessing individual assignments become an onerous task, but it can be reduced to a manageable load if students work together in groups of three and hand in one assignment for the group.

- (x) **Eliminate slogans and target asking for zero defects and new levels of productivity.** Slogans are not really part of a Calculus classroom situation. Yet there is a danger of become cliched by over emphasizing the importance of assessment marks and warning them about how easy it is to fail the course. The move is away from this; the effort is rather spent on motivation and cultivation of a positive attitude amongst students. Zero defect is an impossible quest, rather inspire students to achieve their own potential.
- (xi) **Eliminate work standards / management by objectives. Substitute by leadership.** The success of a course is not measured by the pass rate and a pass rate is definitely not an absolute measure. Pass rates can be manipulated by the degree of difficulty of exams. More emphasis should be placed on built-in quality of learning. In other words, the move is towards quality assurance, away from quality inspection.
- (xii) **Remove barriers that rob people of their right to pride of workmanship / Remove barriers that rob management of their right to pride of workmanship.** For students to perform well it is imperative that they have pride in their work and they should be respected for this. In Calculus in particular a lot of confidence is gained from successfully solving a problem. Pride should also be instilled by respecting their opinion and encourage different and wider thinking and approaches. For the lecturer it is important that he be granted the freedom to break away from the traditional way of doing and not be criticized unduly.
- (xiii) **Institute a vigorous program of education and self-improvement.** This point is obvious for any new approach in education. It is far more par for the course than in industry. Self-improvement is not a luxury in academic life; it is a must and essential for survival. On the student's side the emphasis is here on self-improvement and this can be achieved in a Calculus course through activities such as worksheets and projects that encourage independent work and therefore self-improvement.
- (xiv) **Put everyone in the company to work to accomplish the transformation.** This is the ideal situation. For true success a whole department should be focused towards a transformation with initiative coming from top management. In real life it often happens that a single lecturer initiates transformation and it spreads from there. The whole is greater than the sum of the parts.

## Calculus and Zen

Deming's 14 points do not tell us what quality in Calculus teaching is, only how to improve it. It is Pirsig who sheds light on what is meant by quality work from the students' side. Ask students what a quality course is and they often simply make a Romantic Quality judgement. They like the lecturer or the atmosphere in the class or have friends in the class and therefore feel positive towards the course. Students often do not have the insight or wisdom to make a

Classical Quality judgement. The Classical Quality of a course lies in the student's grasping of the concepts and how well he can apply these and what value it has for his future career. Whereas Romantic Quality judgement may vary from student to student, a Classical Quality judgement is uniform.

Pirsig [5] relates Quality to the Zen philosophy when he talks of "inner quietness" and "peace of mind". These are ideal qualities to cultivate when teaching Calculus. There shouldn't be panic or fear or a lack of self-confidence. An undeniable success story is the inclusion of projects as part of a Calculus course. The majority of students hand in excellent reports that clearly took hours of their time. They seem to find more pleasure in and make time for doing these projects than in preparing for an exam. Is it possible that when a student does a project he reaches a state of inner quietness and a peace of mind that carries him along? He has time and space to think and these are prerequisites for producing quality work.

Students should also be made aware of the idea that Pirsig's "stuckness" is a desirable state to be in. Especially in Calculus, students are often confronted with problems. It does not follow that a student should immediately be able to solve the problem. What is desirable is for the student to spend time on it, experience the "stuckness", and reach a state of Zen that inevitably leads to a way of solving the problem. The student may want to search the textbook or simply turn it over in his mind to approach the problem from different sides. It may even mean that the student realises that he does not understand the underlying concepts and need external help. All this happens without fear and panic. The success of projects and worksheets may also be related to the "stuckness" that Pirsig talks about.

## Conclusion

Although the subject matter of Calculus has not changed for three centuries, the approach to teaching and learning certainly has. The modern presentation is richer and varied and caters better for different abilities and needs. Although not generally practiced, resistance to cliched methods is slowly being overcome. The new approach fits in well with Deming's Quality principles and corresponds to the Zen philosophy.

## References

- [1] Juran, J.M., (1989). *Juran on Leadership for Quality: An Executive Handbook*, Free Press, New York, NY.
- [2] Crosby, P.B., (1979). *Quality Is Free*, McGraw-Hill, New York, NY.
- [3] Ishikawa, K., (1992). *What Is Total Quality Control? The Japanese Way*, Prentice-Hall, Englewood Cliffs, NJ.
- [4] Deming, W.E., (1986). *Out of the Crisis*, Cambridge University Press, Cambridge.
- [5] Pirsig, Robert M., (1989). *Zen and the art of motorcycle maintenance*, Vintage, London.
- [6] Crawford, Lachlan E.D., Shutler, Paul, (1999). Total quality management in education: problems and issues for the classroom teacher, *The International Journal of Educational Management*, 13(2).
- [7] Kwan, Paula Y.K., (1996). Application of total quality management in education: retrospect and prospect, *The International Journal of Educational Management*, 10(5).