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Viewpoint: Towards Total Quality Using Problem-Based Learning

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Much activity occurred in Australian universities during 1993 to grab a share of the $76 million offered by the Federal government for indications of quality *in the university sector. Actually, the money was mostly allocated on the basis of the quality of the quality assurance programs in place. Even more effort is being devoted to the issue in 1994. However, the authors' impression is that most of the effort is in trying to convince the government that quality already exists (it does in most areas), while not necessarily putting in place the necessary cultural change which will lead to continuous quality improvement (particularly in the teaching area). This paper shows that some adaptation of the principles of total quality management (TQM) is a way to achieve quality in teaching. Problem-based learning is shown to be a mechanism which is totally consistent with these TQM principles, and which, by empowering students, can achieve the sort of involvement which has led to significant improvements in quality and productivity in other industries.*

INTRODUCTION

IN 1994, the Australian government again offered around $80 million in additional funding to the universities of the United National System on the basis of their quality in teaching and learning, as well as their quality assurance programs in this area. Some universities have responded to this by seeking quality assurance procedures developed in other service industries. These are typically based on ISO 9000 (and associated standards from the International Standards Organization) or its Australian equivalent AS 3900 (Standards Australia, 1987) [1, 2]. There is, however, a danger that we will fill our lives with bureaucratic procedures, rather than using quality as a means to transform our educational environment.

Deming, the guru of the total quality management (TQM) movement, stressed the importance of *cultural change* in order to gain from a shift to a focus on quality [3, 4]. This issue has been explored by Holecek [5] and Holecek and Hadgraft [6], and is described in some detail later. An important requirement is to *empower* the members of the organization. The remainder of the paper will explain how the ideals of TQM can be implemented in a university environment through problem-based learning, as an effective way of empowering students.

PROBLEM-BASED LEARNING

PBL is well described in books such as Boud and Feletti [7] and Ryan [8], and it has found acceptance in many disciplines, in many different parts of the world. It is an approach with many variations, but the key ingredients are ([9, Table 2]):

- *active* learning through posing questions and seeking answers;
- *integrated* learning by tackling problems for which knowledge of several subdisciplines is necessary;
- *cumulative* learning, by a succession of increasingly more complex problems, working up to those which would be typically handled by a young professional; and
- learning for *understanding*, rather than for the retention of facts, by providing time for reflection, by frequent feedback, and by opportunities to practise the skills which have been learned.

PBL has other benefits, which many of us see as essential to our graduates in their working lives, providing skills in ([9, Table 1]):

- adapting to, and participating in *change*;
- *problem solving* in unfamiliar situations;
- *reasoning* critically and creatively;
- using a *systems*, or holistic approach;
- *collaborating* productively in teams;
- *identifying* one's own strengths and weaknesses, and committing oneself to *lifelong learning* as a means of addressing the problems.

These attributes will be important in the discussion ahead, because it is only through these skills that our students will be sufficiently adaptable in their working lives, and, likewise, the development of these skills gives us (the staff) an opportunity to benefit from our students, rather than see them as a burden.

This paper is not meant to be an in-depth consideration of PBL. Rather, it is an attempt to show how PBL is consistent with the TQM movement, and to indicate that in this new *quality environment* in which we find ourselves, PBL is a means of

achieving benefits from quality which are consistent with those that manufacturing industry has been enjoying for many years. The alternative is a bureaucratic approach that will further reduce the time available to staff, and which will provide only marginal benefits for students.

WHAT ARE QUALITY, QUALITY CONTROL, QUALITY ASSURANCE, TOTAL QUALITY?

Discussions about quality often start with a consideration of *what is quality*? We will avoid this question, because we could spend the rest of the paper on that issue alone, and it is often a rather religious argument. Most of us have some sort of image of what we are trying to achieve in higher education, and the previous section described some of the generic competencies which many of us feel are important. The following discussion is not dependent on any particular definition of *quality*.

What, then, is *total quality*? It means that every aspect of an organization (every task, product or service) must be constantly improved, until it is performed to a high standard. TQM then means managing an organization to achieve total quality.

How does this differ from *quality assurance* and *quality control*? The latter is the *accept/reject* approach typically used at the end of a production line, and it is in common use in universities: an examination is performed, and some products (students) are passed fit for use, and others are tossed in the bin, or in our case, are recycled back to the start of the production line.

Quality assurance takes this another step by monitoring the production line, observing the subprocesses, and deciding where improvements need to be made in order to reduce the number of defectives. In a university, this might mean examining student results each semester, and changing how a course is presented to increase the number passing. At the moment, this is not common. Quality assurance is not normally about redesigning the entire production line, but rather about incremental improvements in the existing one.

Total quality takes this process one step further by recognizing that *all* the members of an organization (including, in our case, the students) can contribute to the process of continuous quality improvement (CQI). The challenge is to harness their enthusiasm to build an effective team where *each* person is contributing.

ESTABLISHING A QUALITY CULTURE THROUGH PBL

At the forefront of the total quality movement are three main leaders: W. Edwards Deming [3, 4], J. M. Juran [10] and A. V. Feigenbaum [11]. Their ideas are similar, and overlap in many instances. Interestingly enough, they have all been active in the area of quality since at least the end of the Second World War, mainly in Japan. Only in the last 10 years have they been accepted widely in the West.

Probably the most prominent TQM model is the Deming Management Method, which is based on *Deming's 14 points*. Though the 14 points were designed mainly for manufacturing industries, they can also be applied to service industries. Tertiary education can be considered a service industry (though with some interesting customer/worker relationships); thus the Deming model can be applied [12, 13]. Each business is a unique enterprise to which these points need to be adapted. However, if we consider them as guiding principles, and not rules, then much can be learned.

Deming's 14 points are considered below, each followed by a commentary on parallels to PBL, and their applicability to universities.

Point 1: constancy of purpose

> *Create constancy of purpose towards improvement of product and service, with the aim to become competitive, to stay in business and provide jobs.*

This is the *cornerstone* of TQM. The organization must have a *clear purpose* which will guide the members of the organization in their daily tasks. If everyone is prepared to work on this premise, and follow the guidelines correctly, the quality of product and service in the organization can only improve. This will then allow the organization to stay competitive and expand and continue to provide jobs.

An important point is that if we are to make progress, we must see our *students* as a part of the university—not just as *customers* as has typically been the case. In fact, students outnumber staff by an order of magnitude, and the total intellectual effort by the students must exceed that of the staff. It is a pity that so much of it is wasted in unproductively repeating what has been done so many times before. We must each share the same vision of what the organization is about—a constancy of purpose. This must be a negotiated vision in which all members (staff and students) can benefit.

PBL is a means of moving towards a student-centred learning process in which the vision of developing those skills discussed earlier, is of paramount importance. We must, however, be careful to make sure that it is a *shared* vision. Even in well-developed PBL environments, there is a danger that the staff setting the overall agenda to an extent where innovation and contribution by the students are severely constrained. This matter has been discussed by Chen [14].

Point 2: adopt the new philosophy

> *We are in a new economic age, created by Japan. Transformation of Western management style is necessary to halt the continued decline of industry.*

'*Nobody* has *to do quality. Survival is not compulsory*.' Deming

The new philosophy is quality. The old philosophy (Western management style) is a work scenario where the manager wants to get the maximum amount of work from a worker for minimum money and the worker's ambition is to do as little as necessary ([15, p. 40]). With the new philosophy, people feel pride in their work and a sense of belonging to their organization. Deming calls quality the *new religion*; thus all people at an organization must be believers, and accept the new philosophy.

Although it could be argued that academic staff have always felt this, the same cannot be said of students. It is crucial that they become effective partners in the process. This will generate pride in their accomplishments and a sense of belonging. This can only happen when the organization's aims are shared by the students. At the moment, student needs are often in conflict with staff ambitions.

Point 3: cease dependence on inspection to achieve quality

Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

Exams at the end of semester are the main form of inspecting the product in most university departments. The result of this inspection may not be conclusive, for example if a student has a bad day or a lucky one. In either case, the exam will not be a true reflection of his/her ability. 'Inspection at the end of a process is too late to ensure quality' ([12, p. 30]). If the product is faulty, and the student fails, much of the semester has been wasted in terms of time and cost. This is not efficient. PBL is much more in tune with this process than the traditional approach. It is based on regular contact between staff and students so that, one would assume, student effort will be well above a pass by the time the work is submitted. This has certainly been the first author's experience.

Point 4: end the practice of awarding business on the basis of price tag

Purchasing must be combined with design of product, manufacturing and sales to work with the chosen suppliers. The aim is to minimize total cost, not merely initial cost.

There is a traditional view of university education that the most efficient system is provided through huge lecture theatres and as little real interaction between the students and staff as possible. (The authors like to think of this as the *McDonald* model of universities—reasonably priced, consistent quality, but not very nutritious.) Rarely is the cost of failure rates of 10–30% in this environment considered. Although a PBL environment may appear to be more expensive to mount, it can have significant paybacks, e.g. reduced costs through lower failure rates, and students contributing to research and publishing. (For example, this paper is the outcome of PBL—a fourth-year project.)

Point 5: improve constantly and forever

Improve constantly and forever every activity in the company to improve quality and productivity and thus constantly reduce costs.

This point is logical, yet can be hard to implement. Members of the organization must try to improve any activity with which they are associated. It is almost impossible to be able to say that any activity is perfect and beyond improvement. It can always be modified or improved. Staff must commit themselves to improving their performance just as we expect this from students. For example, would *you* commit yourself to constantly reducing the time it takes you to return assignments after they are marked or improving your lecture or tutorial style? Likewise, students must commit themselves to continuous improvement—not just in the acquisition of new knowledge, but in improving basic skills, e.g. report writing, seminar presentation, wordprocessing, ability to meet deadlines.

Point 6: institute training

Institute training and education on the job, including education of management.

Universities are not renowned for vigorous training of either general or academic staff. Training can be used to learn new skills such as teaching in an effective manner (academic staff) and carrying out tasks more productively (general staff) ([12, p. 63]). Likewise, every student should be given appropriate training in learning and study skills, the psychology of learning, report writing, teamwork, and so on. It is amazing that institutions devoted to learning should spend so little time discussing the process—not just by those in charge, but also those who are *really* doing the work, i.e. the students. In PBL programs, more effort has been devoted to this issue—partly, one assumes, to distinguish the style of learning in PBL from that of traditional programs. Staff must be updated with new understandings of the learning process so that they can assist students in their learning endeavours.

Point 7: institute supervision

Institute supervision. The aim of supervision should be to help people and machines do a better job.

The word leadership can also be substituted for supervision. The performance of students, in particular, should be supervised by staff equipped to do this (see point 6). This supervision should not be based on authority and fear. Supervision must be helpful, and be seen to come from someone who

is as interested in you doing your job well as you are. This means that the staff in the organization have to be sensitive and helpful in drawing the best work from the students. Good teachers must be able to motivate people and have vision for long-term quality gains. This has long been the goal of postgraduate supervision.

Likewise, leadership can occur at many levels, by both staff and students. PBL, with its natural inclination towards team-oriented exercises, needs good supervisory skills from both students and staff, and, in turn, will continue to develop those skills in both staff and students, to the benefit of both.

Point 8: drive out fear

> *Drive out fear, so that everyone may work effectively for the company.*

Consider the student's fear of failing exams. This results in the student working towards passing exams, rather than studying to understand the material. If fear is reduced (eliminated even?), students are more likely to seek the type of understanding that we feel is so important. If secure, people are less likely to hide mistakes or inefficiencies, and more likely to ask questions and make suggestions. *Trust*, *communication* and *involvement* are all imperative to TQM ([12, p. 81]).

Point 9: break down barriers between departments

> *People in research, design, sales and production must work as a team to tackle usage and production problems that may be encountered with the product or service.*

In universities, there are barriers between academic staff, students and general staff. Input from students should not be minimized as they can have insights that the staff may not have. Another way of looking at breaking down barriers is the way academics are judged mainly on research, and teaching is given little weight. It is difficult to be committed to teaching if all rewards, such as promotion and peer recognition, come from successful research. If this anomaly is reduced, and equal rewards are offered, this could have immense benefits for quality.

PBL is a route for bringing research and teaching closer together; a method for having undergraduates work closer to the leading edge. Well-considered projects at the undergraduate level can result in conference and journal papers. A class of 50–60, for example, can collectively consider a large number of options. In this way, undergraduate students could be contributing to research activities, and increasing the dollars earned from research.

Point 10: eliminate slogans

> *Eliminate slogans, exhortations and targets for the workforce asking for zero defects and new levels of productivity. Such exhortations only create adverse relationships; the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the workforce.*

The problem with slogans is that they are directed at the wrong people ([3, p. 66]). They are directed at workers, whereas Deming believes that most problems in a process (manufacturing, service, etc.) are 85% management/15% worker responsibility [12]. PBL is a positive move by management (staff) to shift responsibility from staff to students. Exhortations such as *study hard for exams* become largely irrelevant. Students themselves take on the responsibility for their own learning.

Point 11: eliminate work standards that prescribe numerical quotas

The numeral quota applicable in our case is the need to attain a pass mark by the student, and if less emphasis was placed on this, the student could attain knowledge of better quality and understanding. Currently, most students are more interested in passing a subject than in understanding it. PBL requires the students to interact with the course material in an integrated way, hopefully leading to deeper, more complete understanding. A satisfactory performance level can be defined in a variety of ways to suit particular students.

Point 12: remove barriers

> *Remove the barriers that rob hourly workers of the right to pride in their work. The responsibility of supervisors must be changed from sheer numbers to quality. Remove the barriers that rob people in management and in engineering of their right to pride of work. This means,* inter alia *abolition of the annual merit rating and of management by objective.*

Students must be empowered to take responsibility for their own learning. This gives them pride in their work, and has traditionally been a role of PBL.

Point 13: institute a vigorous program of education

> *Institute a vigorous program of education and retraining. New skills are required for changes in techniques, materials and service.*

This is self-explanatory (see also point 6). Again, this point applies to *all* people in the organization. This matter cannot be overemphasized. How can we expect students and staff to perform well in the learning facilitation process if each person has such a poor understanding of what *learning* really is. In fact, is learning the same as education? Do we learn naturally in any case, and if so, isn't the role of a university to provide as wide a range of relevant *experiences* (problems) for each student? This type

of experience-based course design in hydrology is discussed in Daniell and Hadgraft [16].

Point 14: put everybody in the company to work in teams

Put everybody in the company to work in teams to accomplish the transformation.

This point is closely related to point 9. Working in teams is successful because people do not wish to let the team down; thus their work is of higher quality and, consequently, the work of the team is better. Working in teams may also create competition between teams which may produce higher quality. Such teams will typically contain both staff and students (often from a variety of levels).

We have traditionally placed students on university committees, but this is often just window dressing. We need to build teams based on respect, where students are recognized as having points of view which are just as relevant as those of the staff. The students also need to feel that such participation is worth the effort.

SUMMARY OF QUALITY REQUIREMENTS

Deming's 14 points are not so much *rules* as guiding principles which can give us a new view of our current activities. The key issues that have come out of this discussion, which are clearly in tune with PBL, are as follows:

- constancy of purpose—a shared (negotiated) *vision* for the university;
- adopt *quality* as a guiding principle;
- *ensure* quality rather than test for quality—get it right the first time!
- choose a teaching method that maximizes the *benefits* minus the costs;
- *improve* constantly;
- institute *training* and education for all members of the organization;
- ensure effective *supervision* for all;
- drive out fear; build *trust* and respect;
- break down *barriers* between departments (e.g. teaching and research);
- eliminate *slogans*;
- ensure pride of *workmanship* and ownership;
- put everyone together to work in *teams*.

If we could achieve all of these things, we would be doing very well. When we read the list, and consider what we are trying to do in PBL (see earlier), there is an excellent match. Hence, PBL is a means of achieving these goals, and a means of building university departments which are committed to quality for the benefit of all its members—academic staff, general staff, and students.

CONCLUSIONS

Much has been written about students as *customers* of education, but little about their role as *workers*. The way in which TQM has been applied in industry suggests that it is important to 'know your customer'. In higher education, we must meet the needs of various interested parties (students, employers, staff, the community), and all of these should have some influence on the content and direction of our courses. Thinking about the students alone, that means that students must be *involved* to some degree in setting course content and process.

Little of this happens now, because we believe they have little to contribute. This is a fallacy. They may have a different opinion from ours, but they see the world from younger eyes, which can provide some valuable insights. They may not see the value of all we have to teach, but are usually receptive if we can point out *why* a particular item or experience is in the course.

When we then think of the students as the shopfloor *workers*, industry again suggests that these people must be involved in the management process. This has been very successful in many industries—quite to the surprise of many managers! It is a process of empowerment and trust building, to the point where the workers feel that when they make a suggestion, then something is likely to happen.

How can this translate into higher education? The authors believe that the same process of bringing the students into the curriculum and course process referred to above, will lead to this type of empowerment. PBL is one such route. Only through these sorts of activities will students play the necessary role in TQM, and only then will the university really gain from a commitment to quality.

Many academics will not believe this, in just the same way that many managers never believed that shopfloor workers could be involved in goal setting and other activities. Yet experiences from those involved in active learning refute this. Students achieve a higher quality of learning experience and the staff enjoy it more. Certainly, there will be staff who will not like it initially. But as their confidence grows, they will realize what can be achieved.

This is a different, but not new, version of higher education. What it does is link the things that have been written about PBL with the TQM movement, to show that they are compatible and consistent—one more reason for moving to some form of PBL. It has worked for industry to many people's surprise. It has worked in higher education in many places. It's time for a change on a wider scale!

REFERENCES

1. International Standards Organization, *ISO 9000—Quality Management and Quality Assurance Standards: Guidelines for Selection and Use.*
2. Standards Australia (1987) *AS 3900: Quality Management and Quality Assurance Standards—Guidelines for Selection and Use*, Sydney, Australia.
3. W. E. Deming (1986) *Out of the crisis*, in Miller [12].
4. W. E. Deming, *New Economics for Industry, Government, Education*, MIT Centre for Advanced Engineering Study, Cambridge, MA (1993).
5. D. Holecek, (1993) Total quality management, Unpublished fourth-year project report, Department of Civil Engineering, Monash University, Clayton, Victoria.
6. D. Holecek and R. G. Hadgraft, Can TQM work in a civil engineering department? *Proc. 5th Annual Conference of the Australasian Association for Engineering Education*, Auckland, pp. 284–289 (1993).
7. D. Boud and G. Feletti, *The Challenge of Problem Based Learning*, Kogan Page, London (1991).
8. G. Ryan (ed.), *Research and Development in Problem Based Learning*, Vol. 1, PROBLARC, Campbeltown, NSW, Australia (1993).
9. C. Engel (1991) Not just a method but a way of learning, in Boud and Feletti [7].
10. J. M. Juran, *Juran on Planning for Quality*, The Free Press—Macmillan, New York (1988).
11. A. V. Feigenbaum, *Total Quality Control*, 3rd edn, McGraw-Hill, New York (1983).
12. R. Miller (ed.), *Applying the Deming Method to Higher Education*, College and University Personnel Association, Washington, DC (1991).
13. S. J. Spanbauer, *A Quality System for Education*, ASQC Quality Press, Milwaukee, WI (1992).
14. Chen Swee-Eng, Profile of an integrated problem-based architecture course—students' perceptions and preferences, *The Technology of Design: Proc. ANZAScA Conference*, Adelaide, pp. 175–187 (1991).
15. F. Price, *Right Every Time*, Gower (1990).
16. T. Daniell and R. Hadgraft, Hydrology toolbox for undergraduates incorporating problem based learning, *Proc 5th Annual Conference of the Australasian Association for Engineering Education*, Auckland, pp. 260–265 (1993).

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