A BLUEPRINT FOR EXECUTING CONTINUAL QUALITY IMPROVEMENT IN AN ENGINEERING UNDERGRADUATE PROGRAMME

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Abstract

This paper focuses on providing a template of how to practice Continual Quality Improvement (CQI) in an Engineering Undergraduate Programme. At the inception of the programme, the academic curriculum is based upon the notion of the type of graduate an institution of higher learning would like to produce. Hence, a graduate of a particular institution embodies its vision and mission. Taking this further and to ensure specificity in the type of graduate produced, Engineering Programmes provide a set of Programme Educational Objectives (PEOs) which are derived from the vision and mission. From these PEOs, the Programme Outcomes (POs) are crafted, followed by the Learning Outcomes (LOs) at the module level – and hence the appropriate curriculum is decided upon. Once the programme is in full implementation, there exists a need to monitor and control the PEOs, POs and LOs to ensure that the programme progresses and evolves. Herein lies the need to practice CQI at all three levels. The following paper will provide an emphasis of how CQI, implemented correctly can result in enhancing the overall student learning experience.

Keywords: Continual Quality Improvement, Programme outcomes, Learning outcomes, Engineering Programme.

1. Introduction

The Chartered Quality Institute defines quality as having attributes in both innovation and care [1]. By innovating new sustainable ways on how to improve a process, this results in a lean operation that satisfies all stakeholders. In order to

reach these goals, it is imperative that a process is monitored, controlled and continually improved. This is normally accomplished by using the well-known Plan-Do- Check-Act (PDCA) cycle [2]. Each part of the cycle has a specific role to play as follows.

> **Plan -** Using a variety of methods (which can include tools and techniques from project management) an implementation plan is crafted. Such a plan would have the goal of continuous improvement of a process.
> **Do -** The "plan" is executed. Data is collected through the various monitoring and controlling mechanism which will be used to address the "check" part of the cycle.
> **Check** - Based on the data collected in the "do" section, an analysis is done to ascertain the success or failure of the "plan".
> **Act** - Upon completion of the "check" part of the cycle, corrective actions are suggested and the entire cycle is repeated.

In an Engineering Undergraduate Programme, it is necessary for the provider of the education to ask themselves; what type of graduate would they want to produce? Such graduates must be aligned to the vision and mission of the university, however as most of these statements are general and apply in its broadest contexts to graduates from a variety of disciplines, engineering programmes craft a set of PEOs which are mapped to the university's vision and mission. The PEOs are what a graduate would need to achieve five (5) years after graduating from the programme – thus in its essence defining the type of professional engineer a university would like to produce. As the PEOs form the foresight of the programme, these statements are used to craft more immediate goals or outcomes called the POs. POs are what a graduate would need to achieve upon graduation from the programme and is mapped to the PEOs. From the POs, the specific academic curriculum is planned and hence lists of module offerings per semester along with the associated LOs are crafted, the LOs of course being mapped to the POs.

Spady [3] stressed about implementing Outcome-Based Education (OBE) approach in engineering education that focuses on equipping the students with the knowledge, competence, and orientations needed for success upon graduation. Fardows [4] also articulated that engineering programmes must function under four broad structures – standards and accountability, curriculum content, instructional process and technology, and the students' eligibility, promotion, and assignment. This is also supported by Rogers [5] who said that "a CQI process involves a clear understanding of mission (who you are, what you do, who you serve), involvement of stakeholders (those who have a stake in the quality of the "product"), clear program educational objectives (after graduation attainment), well-defined program outcomes (acquired desired attributes upon graduation), focused processes (internal practices to enable the achievement of the outcome), facts (data collection focused on performance criteria related to the program outcomes), evaluation (interpretation of results of data collection), and action (feedback to improve processes)". Shuaib et al. [6] reported that University Tenaga Nasional (UNITEN) adopted the PDCA approach in implementing OBE to its Mechanical Engineering programme where PEO, PO, and LO are mapped and assessed using qualitative and quantitative methods. Any shortcomings on the level of outcomes attainment were addressed using the PDCA circle. Open University Malaysia (OUM) for its part used the Pre-input – Input – Process –

Output concept to design an OBE-based module and sent to stakeholders for feedback and improvement [7].

Upon the successful implementation of the programme and knowing that engineering education is driven by OBE, the attainment of the LOs, POs and hence PEOs is of utmost importance for an engineering undergraduate and the faculty. Throughout a student's journey, the attainment of the LOs and the POs can be tracked and trends are observed by the module coordinators. Such trends can either impact the module positively or negatively and a corrective action can be suggested to address such trends in order to assist the module in progressing and evolving.

This paper will detail how the application of the PDCA cycle at the module level flows up to the POs and hence PEOs resulting in a CQI cycle which has the ultimate goal of enhancing the overall student learning experience through continuous improvement.

2. Methodology

Upon establishing the PEOs, POs and the LOs of the programme, a mechanism must be in place to now control and monitor each one to ultimately provide useful data in crafting a CQI action plan for each one. Figure 1 illustrates the CQI loop for the PEO, PO and LO. The responsible person for ensuring the successful completion of the loop is imperative and is further explained.

Referring to the LO CQI loop, upon the commencement of the module at the beginning of a semester, the module coordinator monitors and controls the assessments in the module. Throughout the semester, students are to take part in appropriately weighted assessments which are mapped to the LOs. Assessments are then marked, graded and the LO attainment of each student is calculated based on the marks and the relevant mapping between the assessments with the LOs. The module coordinator is then responsible to critically evaluate the LO attainment of the class and must ascertain whether this meets the expectation. Typically, the expectation is a KPI set by the school. If the module either meets or doesn't meet the KPI, then the module coordinator must provide a CQI action plan that is to further enhance the results for the upcoming semester, hence closing the loop on a semester basis.

Within this loop, a variety of training modules are conducted prior to the commencement of the academic semester encompassing areas such as Assessment, Curriculum Design, Teaching, Learning, Induction and University Teaching and Learning Programmes. These training sessions are made available for all new staff or inexperienced staff upon embarking on the academic field. The main aim is to provide the module coordinator with a platform to execute the primary job functions of a module coordinator which among others includes, to design and effective curriculum, evaluate assessment structures, device assessment methods, perform assessment moderation, grasp a general understanding of the underlying concepts of Outcome Based Education (OBE), to be able to measure student learning time and write appropriate curriculum structures, to be exposed to the various teaching methodologies such as Problem Based Learning (PBL), Project Based Learning (PjBL), to introduce the concept of a student portfolio and to be able to understand and develop new teaching

styles. The execution of these training sessions done on an institution wide manner would be able to prepare the module coordinator with the necessary tools to ensure a smooth flow of job execution during the semester.
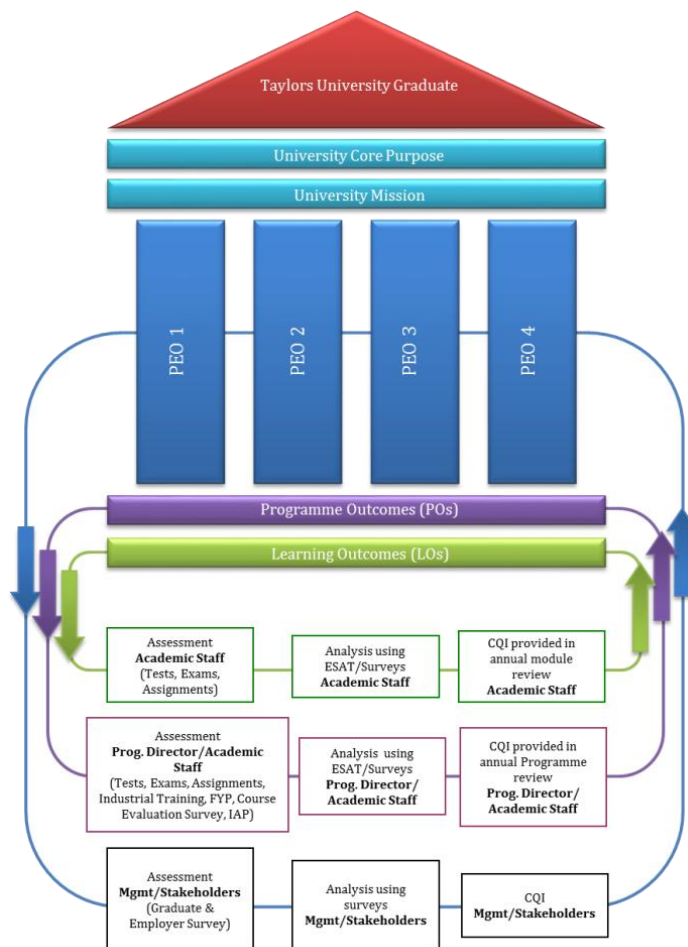

Fig. 1. Continual Quality Improvement Loops.

The above processes are executed for every module in the programme and knowing that each of the modules LOs are mapped to the POs, the PO attainment of an individual student can also be found, which brings us to the PO CQI loop. In this loop, based on data acquired from the module level, the PO attainment of a student can be found. The owner of this loop is the Head of Department or Programme Director who is responsible for suggesting CQI action plans if the PO attainment does or doesn't meet the PO attainment KPI. This loop is closed on a yearly basis. The CQI action plan for this loop will trickle down to the module level and hence the module coordinators play a significant stakeholder role in this loop.

To cater for an effective closure in the CQI loop, training sessions are organised on a school basis to provide a better insight on the various teaching and

learning methods that are school specific. The Teaching, Research, Innovation and Learning (TRIAL) is a compulsory session made available to all staff. The scope of TRIAL is to serve as a platform bringing in strategic tools for lifting the standard of the teacher's role by incorporating research as a teaching tool and to promote innovation in teaching and learning through teaching. TRIAL also serves as a launching platform for some of the school's niche initiatives such as the implementation of Conceive, Design, Implement and Operate (CDIO) in design projects and the CASE based approach in certain modules. In the Teaching (T) component of TRIAL, the SUCCESS approach aimed at developing the "Super Teacher" approach is addressed. This session equips the module coordinator with the ability to construct effective modules, deliver award winning lectures and to expose the module coordinator with the various methods to empower students and eventually unleash their learning power thus guiding the students to a more proactive self-based learning method. The need to shift learning to be more student focused is evident as highlighted in [1]. The Research (R) component of TRIAL is aimed at performing original education research leading to personalising learning to the needs and capabilities of individual learners and to enhance the professional skills of an engineer required for the challenges faced in the 21st century. The Innovation (I) component of TRIAL, advocates the underlying concepts of the Theory of Inventive Problem Solving (TRIZ) while the learning component (L) exposes the module coordinators to the various upcoming challenges that would be imposed upon them by the "Gen Y" students.

In order to generate an effective CQI plan of actions, module coordinators are also required to obtain feedback on their teaching methods from the students. This would be reflected by the Module Evaluation Average (MAV) which is a course evaluation survey performed by the students and is tagged to a certain KPI (the average depending on the administering institution). This online evaluation system together with the soon to be launched Educational Advisory System (EASY) which promotes the idea of a single supervisor for a single cohort of students serves as a method to bridge the gap between module coordinators and the students of a certain cohort. Module coordinators are also strongly advised to employ other methods such as mud – cards, three minute essays, letter to a friend, peer to peer coaching sessions for the rather weak students, sampling of jotter work and others to obtain more frequent feedback from the students. This serves as a tool for the module coordinator to execute immediate remedial measures in order to create a better alignment between the student's expectation and the module coordinator's expectation. Furthermore, the evaluation method as described above crafts a pathway for a high quality CQI action plan that would then ensure the "health" of the module, contributing to the overall "health" of the programme.

The final and largest loop is the PEO CQI loop. In order to monitor and control this loop, a timeframe of at least three (3) years is needed as feedback from employers who have employed the graduates are key in assessing whether the PEOs have been met. The owner of this loop is once again the Programme Director and this loop is normally closed every three (3) to five (5) years. The CQI action plan for this loop trickles down to the PO and LO loops and affects external employers, hence external and internal stakeholders are engaged as well before implementing the CQI action plan at the PEO level.

The primary objective of this loop would be to ensure that the graduate is able to attain the minimum (worst case scenario) PEO KPIs. Throughout the student's journey the attainment of PEOs would reflect the institution's mission and the institution's core purpose which would then be directly benchmarked to the institution's graduate capabilities.

3. Results and Discussion

To further describe the process highlighted in the preceding section, a detailed step-by-step guide on each loop and how it is implemented would now be discussed.

Taking a single module to describe the LO loop. Upon receiving the LO attainment scores for the cohort, the module coordinator then proceed to fill in a formal document which details the CQI action plan based on the LO and PO attainment scores of the cohort. The CQI action plan if then discussed with the Programme Director for initial input. The next step will entail the module coordinator discussing the action plan with the academic staff of the programme for further input. This is called the CQI programme meeting whether observations can also be made the PO level to see if there are trends at the PO level. Upon completion of the meeting, staff then proceed to complete and update the action plan which is endorsed and approved by the Programme Director and is actionable in the upcoming semester. At the end of the future semester, the module coordinator will have to elaborate on the success or failure of the action plan before recommending another one. This entire process is illustrated in Fig. 2.

With respect to the PO loop, the Programme Director tracks the PO attainment of the cohort and provides an overall CQI report on a semester basis. At the end of the year, the Programme Director then provides a CQI action plan for the programme at an annual Programme Review Meeting. The action plan is discussed with the schools management for initial input. The plan is then discussed with the programme's academic staff prior to being finalised. Certain action plan would then require endorsement an input from internal (Staff, Students, Senate) and external stakeholders (Industrial Advisory Panel, External Examiners, Parents, etc.).
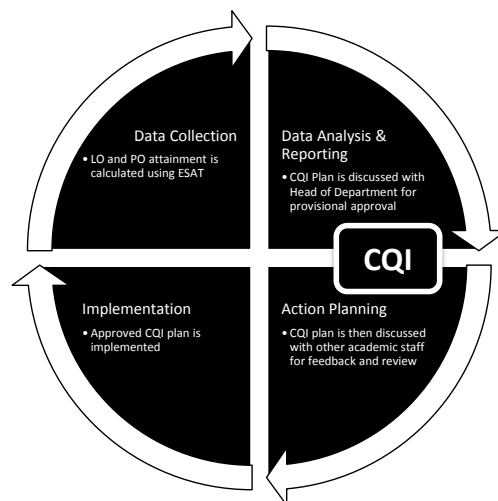

Fig. 2. Module Level CQI Loop.

The final PEO loop is looked after through the engagement of various employers who will eventually hire the graduates. A detailed PEO survey is crafted to address the attainment of the PEOs. The attainment of the PEOs are based on a set of specific and measurable PEO KPIs. The fulfillment of these KPIs (the number of which depends on the administering institution) would then lead to the fullfillment of the PEOs. Once again, based on the feedback from these surveys, input is to be sought from both internal and external stakeholders prior to making any changes and this normally occurs three (3) after the student would have graduated.

4. Conclusions

The availability of LO and PO as well as PEO attainment data clearly expresses the ability of engineering programmes in being able to accurately measure each of its students LO, PO and PEO attainment. However, the presence of this data alone does not make any impact on the engineering programme itself unless it is used in further enhancing and evolving the programme, hence the need for CQI. The ability of using such data in CQI must be coupled with a clear monitoring and controlling process in place that involves the necessary stakeholders. In addition to this the programme owner (normally the head of deaprtment) must be accountable for the execution of the CQI action plan at all levels, i.e. LO, PO as well as PEO CQI plans.

References

1. Perry, W.; Broers, A.; El-Baz, F.; Harris, W.; Healy, B.; and Hillis, W.D. (2008). Grand challenges for engineering. National Academy of Engineering, Washington, DC.

2. Sokovic, M.; Pavletic, D.; and Pipan, K.K. (2010). Quality improvement methodologies – PDCA Cycle, RADAR Matrix, DMAIC and DFSS. *Journal of Achievements in Materials and Manufacturing Engineering*, 43(1), 476-483.

3. Spady, W.G. (1994). *Outcome-based education: Critical issues and answers*. American Association of School Administrators, Arlington, USA.

4. Fardows, N. (2011). Adaptation of outcome based assessment system at undergraduate level. *Research Journal of International Studies*, 19.

5. Rogers, G. (2010). Continuous quality improvement in engineering education: Fact or fiction? *American Society for Engineering Education*.

6. Shuaib, N.H.; Anuar, A.; Singh, R.; and Yusoff, M.Z. (2009). Implementing continual quality improvement (CQI) process in an outcome-based education (OBE) approach. *Proceedings of the 2nd International Conference of Teaching and Learning* (*ICTL* 2009), INTI University College, Malaysia.

7. Khalid, H.M.; Abas, Z.W.; and Zulkifly, M. (2007). Improving the quality of learning modules: a continuous process. Open University Malaysia. Available on http://eprints.oum.edu.my/107/.