

# IMPLEMENTATION OF CONTINUOUS QUALITY IMPROVEMENT (CQI) IN ENGINEERING MATHEMATICS COURSE AT POLITEKNIK KOTA KINABALU

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**Abstract:** *The main purpose of this study is to identify the impact of Continuous Quality Improvement (CQI) implementation on End-of-Chapter (EOC) coursework assessment for Engineering Mathematics 1 course in Politeknik Kota Kinabalu, Sabah. The research design is descriptive quantitative by using data review strategy. The data acquisition method is done by collecting the mean score of students' achievements in EOC assessment by sessions and classes for each CQI that has been implemented. The respondents involved were first semester engineering students of Politeknik Kota Kinabalu. Data were analyzed using SPSS version 26 to obtain the mean achievement score of the students' EOC assessment by session with implemented CQI. The results of the study found that Aim Peer Collaborative is the best proposed CQI with the highest mean score achievement. Aim Peer Collaborative shall remain its implementation for EOC in future sessions.*

**Keywords:** *CQI, End of Chapter, Impact, Coursework Assessment, Engineering Mathematics*

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## Introduction

Continuous Quality Improvement (CQI) is the ninth area in the accreditation framework implemented by the Malaysian Qualifications Agency (MQA) (Thong, 2013; Salleh & Rani, 2019) which was established to give recognition to Higher Education Grants (PPT) that meet the criteria and standards set in the Malaysian Qualifications Framework (MQF) to guarantee the quality of the programs offered (Act 679, 2007). CQI generally refers to continuous efforts to improve products, services, or processes (McLaughlin & Kaluzny, 2004; O'Neill & Palmer, 2004; Daud et al., 2020). Continuous Quality Improvement (CQI) in Engineering Mathematics 1 of Politeknik Kota Kinabalu (PKK) aims to improve the Course Learning Outcome (CLO) that has been outlined in the course syllabus. Three CLOs have been mapped with their

respective summative assessment methods and CLO achievement target in percentage as shown in Table 1.

**Table 1: Mapping of CLOs to the Assessment Method**

	<b>Course Learning Outcome (CLO)<sup>1</sup></b>	<b>Assessment Method</b>	<b>CLO Achievement Target (%)</b>
CLO1	Use mathematical statement to describe relationship between various physical phenomena.	Quiz and Final Exam	65
CLO2	Show mathematical solutions using the appropriate techniques in mathematics.	Test, End-of-Chapter and Final Exam	65
CLO3	Use mathematical expression in describing real engineering problems precisely, concisely and logically.	Presentation	70

End-of-Chapter (EOC) is one of the summative assessment methods used to evaluate students CLO2 achievement at the end of a topic which will subsequently be awarded a grade. There are three EOC assessments with a weightage of 20 percent out of 60 percent Coursework Assessment (CA) overall marks. In Politeknik Kota Kinabalu, the proposed topics for EOC is defined in Table 2.

**Table 2: Proposed Topics for End-of-Chapter Assessment**

<b>Weightage (%)</b>	<b>End-of-Chapter</b>	<b>Proposed Topic</b>
20%	EOC 1 <sup>2</sup>	Topic 1 Basic Algebra
	EOC 2 <sup>3</sup>	Topic 3 Complex Number
	EOC 3 <sup>4</sup>	Topic 4 Matrices

Engineering Mathematics 1 is a course that students must take in the 1st semester of Electrical Engineering and Mechanical Engineering at the Polytechnic. However, based on the final exam results of the students of the previous semester for the Engineering Mathematics 1 course at Kota Kinabalu Polytechnic, their achievements did not reach the target of 100% passing. The results found that the student's grade achievement level was less than satisfactory and only obtained the minimum result to pass. Some students failed this Engineering Mathematics 1 exam. This result is in line with the findings of a study by Parsons and Adams (2005) who found a high failure rate for Mechanical Engineering subjects as well as mathematics subjects

<sup>1</sup> Engineering Mathematics 1 (DBM10013) is a common core subject to all engineering programmes in Politeknik Kota Kinabalu. There are three CLOs outlined for Engineering Mathematics 1 that has been summarized (Programme Handbook PKK, 2021). The CLO2 requires students to show mathematical solutions using the appropriate techniques in mathematics. One of the summative assessment methods used to determine student's ability to demonstrate the problem-solving solution is called the End-of-Chapter (EOC). It is termed EOC in conjunction to a particular topic ending assessment

<sup>2</sup> EOC construct: i. Show procedures to find partial fractions.

<sup>3</sup> EOC construct: i. Demonstrate the operation of complex number. ii. Demonstrate graphical representation of a complex number through Argand Diagram. iii. Write complex number in other form.

<sup>4</sup> EOC construct: i Construct matrix. ii. Demonstrate the operation of matrices. iii. Demonstrate simultaneous linear equations

in engineering students (Zeidmane & Rubina, 2017). Therefore, this study was conducted to identify the CQI that needs to be implemented to improve the achievement of the Engineering Mathematics 1 course among polytechnic students in Sabah.

### Problem Statement

Table 3 shows the achievement of EOC1, which obtained the lowest mean score of 82 percent compared to EOC2 (94.3 percent) and EOC3 (90.2 percent) in the June 2019 session. EOC1 declined to the lowest point of 59.9 percent in the December 2020 session, along with EOC2 (77.7 percent) and EOC3 (77.0 percent) at the end of the fourth session. Based on this score, it is seen that there is a decline in academic achievement for the subject Engineering Mathematics 1.

**Table 3: EOC Achievement Trend (June 2019 – December 2020 Sessions)**

Session	EOC	N	Mean Score (%)	SD	Implemented CQI For EOC
Jun-19	1	490	82.0	15.44	No CQI was proposed when the refined syllabus took effect.
	2		94.3	4.41	
	3		90.2	10.78	
Dec-19	1	207	77.1	13.10	No proposed CQI for EOC since CLO2C was at high attainment compared to June 2019.
	2		82.2	5.94	
	3		92.3	7.71	
Jun-20	1	249	76.5	18.00	No proposed CQI for EOC since the CLO2C achievement improved in June 2020 compared to December 2019 session.
	2		82.9	15.36	
	3		84.1	15.14	
Dec-20	1	309	59.9	12.47	<i>EOC1 Drill</i> has been proposed to be implemented in the next academic session.
	2		77.7	12.68	
	3		77.0	9.52	

In fact, seven academic sessions have completed its cycles since the Engineering Mathematics 1 syllabus took effect in June 2019. Unfortunately, there were no proposed CQI to improve EOC achievement since June 2019 until December 2020 sessions in Politeknik Kota Kinabalu. It was because CLO2 continuously reached its set target of 65 percent achievement and even higher within the sessions. However, it raises concern when EOC1 constantly scores the lowest among other EOCs since June 2019. Currently, without clear indicators, it is difficult for lecturers to set CQI requirements. Hence, based on the achievements of the last semester, a guideline has been made as a recommendation to CQI. Implementation of CQI has been taken with the intention of improving achievement performance for each EOC. Therefore, the objectives of this study are:

- i. To identify the CQI implementation requirements for Engineering Mathematics 1.
- ii. To identify the impact of the implementation of the proposed CQI on EOC achievement for Engineering Mathematics 1.
- iii. To identify the most effective CQI on EOC achievement for Engineering Mathematics 1.

## Literature Review

Quality is an important agenda at every level of education. The co-curricular curriculum has undergone several changes and development phases in line with current needs and changes. That includes the aspects of code and inventory changes, the content of changes and the assessment form. It is part of continuous improvement (Continues Quality Improvement - CQI) in line with current requirements. Quality improvement efforts should always be carried out continuously by focusing on the following things, namely the development of the infrastructure necessary to implement improvements on an annual basis, identifying specific areas that require improvement, and implementing improvement projects because each area requires a different improvement project (Mohamad et al., 2017). This continuous quality improvement effort should be seen as an organizational management strategy to improve work processes to provide customers with better quality services (Sibbald et al., 2013). Previous studies show a positive relationship between quality improvement strategies, management perception, customer involvement, and information quality improvement to create a competitive advantage for the organization to achieve a high-quality status (Goetsch & Davis, 2016). According to Zainul Rashid et al. (2015), quality assurance in P&P plays an important role in ensuring that the main procedures in the higher education curriculum are implemented according to the standards that have been set. Therefore, it is the responsibility of all lecturers to be concerned about implementing quality assurance at the higher education level to produce quality and competitive students. Therefore, the polytechnic credit curriculum transformation plan was further implemented in 2014 to respond to the challenge of continuous quality improvement (CQI) (Yusak et al., 2019).

CLOs are elements of technical or soft skills that each student must acquire prior to completion of a specific course or subject taught (Musid, 2019; BIPD, 2020). CLO is designed to support and be measurable against Program Learning Outcome (PLO) (Aburas, 2021; Zaki et al., 2023). Various strategies and teaching methods should be applied, and individual plans should be adapted to meet the course's learning outcomes, including strengthening Continuous Quality Improvement (Liew et al., 2021). Continuous Quality Improvement (CQI) at the institutional level is a process of regularly reviewing and updating the Higher Education Providers (HEP) activities to assure and improve quality through applying the CQI stages of 'plan', 'implement', 'monitor and review', and 'improve'. (MQA, 2014). The CQI plan implementation concept at institutional level is developed based on the Deming Cycle PDCA Model (1950). This model produces an objective, effective and continuous processes. The PDCA model includes processes; Plan, Do, Check and Act. According to Foster (2011), CQI is important in refining the achievement of a course. CQI is an ongoing process based on the feedback and needs of various stakeholders. The Engineering Accreditation Council (EAC) and the Washington Accord are the most important external stakeholders behind developing OBE and CQI for engineering programs in Malaysia (Mutalib, 2019).

## Methodology

This research uses descriptive quantitative design with data review approach. The data acquisition method is done by collecting the mean score of students' achievements in EOC summative assessment by sessions and classes for each CQI that has been implemented. The respondents involved were first semester engineering students of Politeknik Kota Kinabalu from June 2019 session until the latest complete academic cycle Session 1: 2022/2023 ranging between 200 to 400 total students. Data were analyzed using SPSS version 26 to obtain the average mark or mean score achievement of the students' EOC assessment by session before and after the implemented CQI. The achievement trend of EOC1 from June 2019 until December 2020 session without CQI implemented is depicted in graphical representation. The

mean scores beginning December 2020 session onwards were matched with the interpretation table establish based on the mean score achieved from previous sessions (June 2019, December 2019, June 2020 and December 2020 sessions). For objective 1, the data is interpreted in mean score based on Table 4.

**Table 4: Interpretation of Mean Score for CQI Requirement**

Mean Score (%)	Status	Interpretation
90 - 100	Excellent	CQI is not necessary
80 - 89	Good	CQI is not necessary
70 - 79	Average	CQI implementation can be considered
60 - 69	Poor	CQI is required
Below 59	Very Poor	Critical requirement for CQI

For objective 2, three types of CQI were selected and implemented to see the impact on EOC achievement. The first CQI targeting particularly for EOC1 called the EOC1 Drill was implemented in Session 1:2021/2022, and the mean score achievement was collected and analyzed. The second CQI termed the Aim Peer Collaborative was executed in Session 2:2021/2022 and Session 1:2022/2023 aiming at all EOC1, EOC2 and EOC3. The average marks were gathered and subsequently examined. While for the third objective, the results of the most effective CQI on EOC achievement will be shown in the chart.

### Findings

The results of the analysis in this study are divided into three according to the objectives of the study, namely:

- i. The CQI implementation requirements for Engineering Mathematics 1.
- ii. The impact of the implementation of the proposed CQI on EOC achievement for Engineering Mathematics 1.
- iii. The most effective CQI on EOC achievement for Engineering Mathematics 1.

#### i. The CQI implementation requirements for Engineering Mathematics 1.

**Table 5: Mean Score Status and Requirement for CQI**

Session	EOC	N	Mean Score (%)	Status	Requirement For CQI
Dec-20	1	309	59.9	Poor	Critical requirement for CQI for EOC1
	2		77.7	Average	
	3		77.0	Average	
Session 1 2021/2022	1	360	67.8	Poor	CQI is required
	2		66.3	Poor	
	3		76.4	Average	
Session 2 2021/2022	1	218	69.8	Poor	CQI is required
	2		67.4	Poor	
	3		65.8	Poor	
Session 1 2022/2023	1	340	83.0	Excellent	CQI is not necessary
	2		89.0	Excellent	
	3		91.3	Excellent	

Table 5 shows the findings of mean score achievement status and the requirement for CQI. The requirement of CQI is identified by matching the achieved mean scores to Table 4 mean score interpretation. CQI is critically required specifically for EOC1 due to its poor achievement status of 59.9 percent in December 2020 session. *EOC1 Drill* was proposed to be implemented in Session 1:2021/2022. The mean score achievement level in Session 1: 2021/2022 for EOC1 and EOC2 were poor while EOC3 was at average level. Therefore, CQI is required to be implemented in Session 2: 2021/2022. The proposed CQI was *Aim Peer Collaborative* targeting to improve EOC1 and EOC2. In Session 2: 2021/2022, all EOCs attained poor level mean scores and therefore CQI is required. *Aim Peer Collaborative* has been decided to be resumed its implementation in Session 1: 2022/2023. The mean score achievement for all EOCs in Session 1: 2022/2023 ranging from 80 to 100 percent places them at excellent level of interpretation and CQI is not necessary in the following session.

**ii. The impact of the implementation of the proposed CQI on EOC achievement.**

**Table 6: Mean Score of EOC After CQI Implementation**

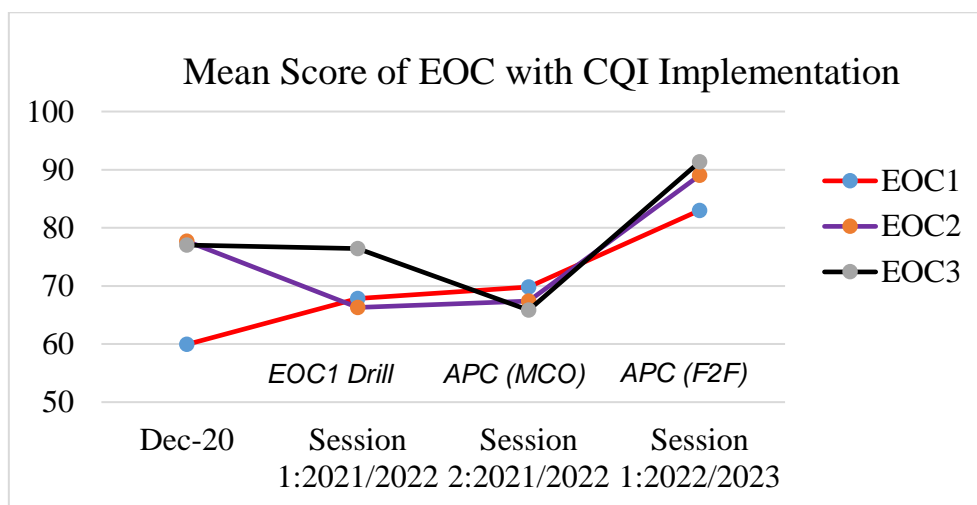
Session	EOC	N	SD	Implemented CQI	Result Mean Score (%)
Session 1 2021/2022	1	360	8.13	EOC Drill (MCO)	67.8
	2		17.53		66.3
	3		16.75		76.4
Session 2 2021/2022	1	218	11.41	Aim Peer Collaborative (MCO)	69.8
	2		14.64		67.4
	3		14.03		65.8
Session 1 2022/2023	1	340	13.56	Aim Peer Collaborative (F2F)	83.0
	2		8.47		89.0
	3		10.74		91.3

Table 6 shows the mean score of EOC with CQI implementation. The mean score data for EOC1 obtained from the implementation of CQI *EOC1 Drill* in Session 1: 2021/2022 shows an increase of 7.9 percent compared to the previous session (December 2020 Session). EOC2 and EOC3 shows a slight downturn most likely due to CQI applied for only EOC1. *Aim Peer Collaborative* was decided as the subsequent CQI for Session 2: 2021/2022 targeting to improve the mean score achievement of all three EOCs. The *Aim Peer Collaborative (APC)* implemented in Session 2: 2021/2022 mean score results show an increase of 2 percent (67.8 to 69.8 percent) for EOC1 compared to the previous session (Session 1: 2021/2022). EOC2 shows 1.12 percent increment from 66.29 percent to 67.41 percent while EOC3 dropped to an appalling 10.61 percent for unidentified cause.

*Aim Peer Collaborative (APC)* was remained as the CQI in Session 1: 2022/2023. It was due to the restrictions on the previous implementation, namely during the Movement Control Order (MCO) throughout the pandemic where students were only managed to discuss as groups in online mode. The EOC1 mean score in Session 1: 2022/2023 (83 percent) showed a major increase of 13.2 percent compared to the previous session (Session 2: 2021/2022 – 69.8 percent). While EOC2 and EOC3 also depicting tremendous hike of 21.6 percent and 25.51 percent respectively.

**iii. The most effective CQI on EOC Achievement for Engineering Mathematics 1**

Diagram 1 shows the graphical representation of EOC mean score achievement before the implemented CQI in December 2020 and after the implemented CQI in Session 1: 2021/2022 until Session 1: 2022/2023. This chart shows that *EOC1 Drill* only contribute to one targeted assessment and affecting EOC2 and EOC3 achievement. As *Aim Peer Collaborative* was executed in Session 2: 2021/2022, it only shows slight increment in EOC1 and EOC2 but a downfall in EOC3. This is most probably due to implementation of CQI during the MCO where face-to-face discussion was restricted causes invalidity of the CQI achievement. It was therefore *Aim Peer Collaborative* resumed its implementation in Session 1: 2022/2023 where face-to-face discussion was allowed during the EOC assessment. This shows that *Aim Peer Collaborative* done in face-to-face mode is the best implementation compared to *EOC1 Drill* and *Aim Peer Collaborative* online mode.



**Diagram 1: Mean Score of EOC with CQI Implementation**

**Conclusion**

In conclusion, CQI was critically required as December 2020 ended especially when EOC1 scored a fall of 59.9 percent. CQI is still required in Session 1: 2021/2022 and Session 2: 2021/2022 due to the poor mean score level. As Session 1:2022/2023 ended, mean score shows the hike of over 80 percent where CQI is not necessary. After the implementation of *EOC1 Drill*, the impact of CQI concentrating one particular assessment can improve the achievement of target matter but affecting the non-targeted subject with the common course learning outcome. *Aim Peer Collaborative* on the other hand shows a poor mean score when done in online mode and better when it was done face-to-face. Drill practices and exercise or drill questions in engineering Mathematics particularly in showing procedures to find partial fraction apparently halt problem-solving pace and an increase in effort due to the item high cognitive and difficulty level. Apart from that, drill practices are time and energy consuming not only for students but to the lecturers as well. Therefore, drill questions are not suitable and unpractical to improve student's performance in expressing partial fraction solution. Face-to-face peer collaboration in groups of students proven to be the most effective and practical CQI to be applied for EOC assessment provided that at least one student function as mentor chosen based on their mathematical background ability. Hence, *Aim Peer Collaborative* has been remained as the CQI for Politeknik Kota Kinabalu to be implemented in the subsequent academic session.

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