International Journal of Science and Engineering Applications
Volume 13-Issue 12, 12 – 16, 2024, ISSN:- 2319 - 7560
DOI: 10.7753/IJSEA1312.1004

Quality Optimization in Higher Education Using DMAIC Analysis

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Abstract: This paper explores the application of Six Sigma methodology to optimize the quality in higher education institutions, particularly focusing on reducing graduation time of M.sc students. By employing the DMAIC (Define, Measure, Analyze, Improve, Control) framework, this study analyzes student performance data from Benghazi University to identify key factors contributing to delayed graduation. Pareto diagram was used to analysis determines the most significant factors. The findings suggest that both of conflict disruption supervisors and references availability are the main factors that contribute most of graduation delay. ANCOVA was used to analyze the graduation time delay with respect to supervisor and references availability while controlling the effects of disruptions. ANCOVA revealed that student may delayed about 4 months for each year of war. Moreover, significant reduction achievement in average graduation delay by1 year for students with excellent supervisor availability / low, and about 10 months with excellent references availability/low. Improvement strategies were suggested to enhance educational processes expressed in shorter graduation times

Keywords: Higher Education, Graduation Time, DMAIC, Quality Improvement, ANCOVA Analysis

1. INTRODUCTION

Higher education institutions worldwide strive to improve the quality of their academic programs while ensuring that their students graduate on schedule. However, many universities need help meeting these objectives, particularly in completing graduate programs on schedule. Delayed graduation can lead to increased financial obligations for both students and institutions, lower student satisfaction, and possibly even damage the institution's image. In this perspective, the Benghazi University case is very pertinent. Over the last decade, the institution has seen considerable delays in the graduation of its M.Sc. students. This issue has made an exhaustive search necessary to pinpoint the root causes of these delays and develop strategies to address them. For process optimization and quality improvement, the Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control) methodology provides an organized approach. Six Sigma was originally developed for the manufacturing industry, but it has been successfully applied in several other fields, including healthcare, finance, and education. The DMAIC technique focuses on detecting and removing defects to reach near-perfect quality. The purpose of this study is to apply the Six Sigma DMAIC methodology to the higher education process at Benghazi University, with a special focus on M.Sc. students' graduation times. Using control charts to measure process capabilities and Pareto analysis to identify significant factors, this study seeks to supply practical suggestions for reducing graduation times and improving academic performance in general. The purpose of this study is to apply the Six Sigma DMAIC methodology to the higher education process at Benghazi University, with a special focus on M.Sc. students' graduation times. Using control charts to measure process capabilities and Pareto analysis to identify significant factors, this study seeks to supply practical suggestions for reducing graduation times and improving academic performance in general.

2. LITERATURE REVIEW

The application of Six Sigma in higher education is a relatively new but rapidly growing field. Antony and Banuelas (2002) noted Six Sigma's potential for improving university administrative and academic procedures. They focused on Six Sigma's capacity to identify significant areas for improvement and streamline processes.

Pande, et al (2000) emphasized the importance of data-driven techniques in education. They proposed that Six Sigma may assist institutions in discovering inefficiencies and improving both student outcomes and operational efficiency, laying the groundwork for future studies into Six Sigma in higher education. Also, Several studies have illustrated the successful application of Six Sigma in universities. Sanders and Hild (2000) found that Six Sigma enhanced administrative operations at a large institution, resulting in increased student satisfaction and reduced processing times for student services. Hoang, Igel, and Laosirihongthong (2006) revealed that Six Sigma initiatives for curriculum design and scheduling in Asian colleges significantly improved student performance and satisfaction. In addition, Six Sigma applications were studied by Nonthaleerak and Hendry (2006) in several service industries, including education. They emphasized the necessity of a systematic approach to process improvement by highlighting important success elements, including managerial commitment and efficient training. In another study, Tribus and Pirasteh (2006) concentrated mainly on using Six Sigma to enhance the quality of higher education, especially addressing problems like resource allocation and delayed graduation dates. Dale, Van der Wiele, and Iwaarden (2007) underlined the necessity of a comprehensive strategy for graduate program quality management that integrates administrative and academic procedures. Moreover, Kumar and Antony (2008) compared quality management approaches across SMEs and larger organizations, revealing insights that might be applied to higher education settings. Chakrabarty and Chuan (2009) concluded that Six Sigma initiatives in

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Singaporean educational institutions resulted in lower dropout rates and faster graduation times, demonstrating Six Sigma's ability to improve educational quality.

Recent research has continued to investigate Six Sigma's influence on higher education. Zhang, et al (2011) found that Six Sigma efforts increased student satisfaction and academic achievement. Kumar, et al (2011) also developed a methodology for implementing Six Sigma in SMEs, including educational settings. Antony et al. (2012) discussed the adoption of Lean Six Sigma in higher education, identifying challenges and success factors. Finally, Stevenson (2012) presented an overview of operations management, highlighting the value of an organized approach to process improvement. Seow, Pan, and Koh (2014) found that quality management approaches like Six Sigma considerably improve the efficiency of educational processes, leading to better student results and satisfaction.

3. METHODOLOGY

This study employs the DMAIC framework to assess and improve quality in higher education, with a particular focus on optimizing graduation time. The case study focuses on a sample of M.Sc. students from Benghazi University over ten years (2012-2022). various tools and techniques used for analyzing the case study, some of these tools are control charts, Pareto analysis and ANCOVA.

3.1 Define

The study addresses delays in M.Sc. graduation times at Benghazi University, impacting student satisfaction and institutional efficiency. The objective is to identify factors contributing to these delays and propose a new learning program to improve graduation rates. Figure.1, illustrate Critical to Quality CTQ tree of the process. The voice of the customer (VOC) is converted into a CTQ metric, i.e. Time of graduation is measured as:

• CTQ-1: The average of years spent to graduate.

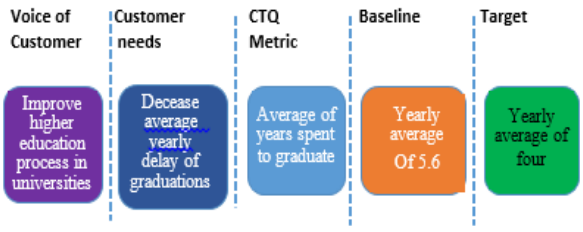

Figure 1. Critical to quality tree.

3.2 Measure

In the Measure phase, historical data on CTQ (i.e, completion times) is collected from a sample of M.Sc. students of Benghazi University over ten years (2012 to 2022); Control charts are used to assess process capability regarding graduation times (CTQ).

▪ Control chart:

Control charts of graduation times are plotted to determine whether the process meets the specifications, Figure.2. Control chart shows a controlled process with mean of 5.6 years and upper and lower control limit of 8.2, 2.9 years respectively.

Figure 2. Control chart of graduation time.

Baseline value for CTQ i.e. the average of years spent to graduate of the current process is 5.6 years. This research seeks to improve this baseline value with a target value for CTQ of 4 years.

3.3 Analysis

In the analysis phase of DAMIC cycle significant factors which contribute in this problem (i.e. delay in graduation time) will be identified. Once the significant factors are identified, they can be controlled and optimized. There are various factors or parameters of the process that expected affecting the time of graduation process in master degree. Some of these parameters were conducing from a preliminary session of brainstorming engaged M.sc students and other stakeholders, as follows:

- Student (e.g. research writing skills, language proficiency, undergraduate performance)
- Supervisor (availability, efficiency, communication)
- Facilities avaialbity (references, research data)
- Others (Conflict Disruptions; wars and sit-in)

Subsequently, the analysis process will be of three stages. First a preliminary study by a fishbone analysis is considered to highlight the possible root causes of the problem, followed by a Parteo analysis to be familiar with the most contributing causes. At the last, ANOCA is introduced to explore the significance of these causes levels on the delay in graduation time.

▪ Fishbone Analysis

A Fishbone analysis is conducted using the collected data from a sample of M.SC students of Benghazi university

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was surveyed in order to validate the possible causes. The respondents were asked to highlight the possible causes of their delay which listed in questionnaire and to suggest others, if any. A number of possible causes contributing to delay in time to graduation were identified and depicted in a fishbone diagram shown in Figuer.3.

Figure 3. Fish bone diagram.

- Pareto analysis

After the several potential causes of the problem were identified, a Pareto chart is used to identify the most significant factors (i.e. causes that have more contribute to the problem). Figure.4. shows the pareto chart for this study, the frequencies of each cause is simply calculated from the responses of the questionnaire.

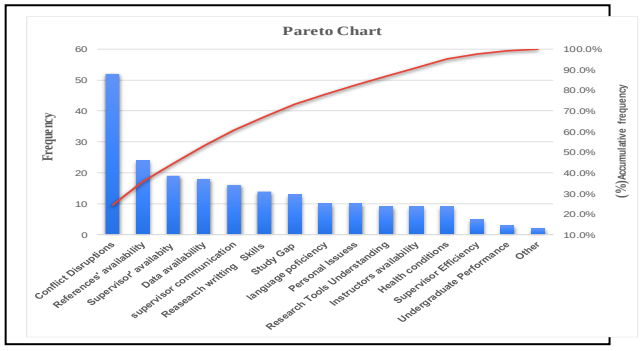

Figure 4. Pareto Chart.

Pareto chart indicates that both of conflict distributions, supervisor availability, and lack of recent references are the causes that contribute most to the delay of the student.

- ANCOVA analysis

ANCOVA was used to analyze the graduation time delay with respect to supervisor availability and resources availability while controlling for the effects of interruptions due to wars and sit-in. This approach allows understanding the impact of supervisor and references availability on graduation delay, adjusting for external interruptions. Three levels were assigned for each factors as demonstrated in Table1. Results of ANCOVA are illustrated in Table.2

Table 1. Factor Levels of ANCOVA

Factor / Levels	Supervisor Availability	Recourse availability	War interruption
1	High	High	long
2	Medium	medium	Medium
3	Low	low	Short

Table2: Results of ANOVA

Coefficients	Value	P-value
Intercept	0.71	0.198
Supervisor_ Availability	-0.41	0.021
Resources_ Availability	-0.04	0.844
War Interruptions	1.62	0.000

-Intercept: The expected graduation delay for students with "low" Supervisor and Resources availability and no war interruptions.

-Supervisor _Availability: Graduation delay decreases by 0.41 years with each level increase in supervisor availability (e.g., from "low" to "medium"), which is statistically significant.

-Resources _Availability: Not statistically significant, indicating minimal impact on graduation delay.

-War Interruptions: Each additional year of war interruptions increases graduation delay by 1.62 years, which is highly significant.

3.4 Improve

The improvement phase aims to develop and implement a comprehensive strategy that addresses the underlying reasons for delayed graduations identified in the analysis phase. We seek to create an efficient, student-centered academic environment that promotes timely completion by implementing a proposed recommendations that contribute effecting to improve the level of the university and students at the same time.

1. Enhance Research Infrastructure:
   - Boosting library resources by adding more books and scholarly journals in printed and digital forms, and make sure they are often updated.
   - Providing research databases to make it easier for people to obtain the most recent information, and subscribe to international research databases.
   - The upgrade provides labs with the tools and apparatuses required to carry out scientific research.

- Offering students training courses to learn how to access databases and carry out research.

2. Streamline Administrative Procedures:

- Using electronic systems to handle student requests and assign supervisors.
- Establishing clear timetables for each stage of the supervisory assignment process, in addition to monitoring and evaluation mechanisms.
- Training administrative workers on new procedures.

3.5 Control

Finally, the Control phase ensures that improvements are sustained over time and that graduation times have been decreased. The results could be communicated to the team and the decision makers could be directed to run the education process under the suggested factors' setting.

4. RESULTS

The analysis revealed several areas for improvement, including e.g. research writing skills, language proficiency, undergraduate performance of the students, availability of supervisor, references and data. Another cause was identified, which is Conflict Disruptions; wars and sit-in).

- Pareto analysis identified key factors contributing to delays; supervisor availability, references availability and disruptions due to wars and sit-in. ANCOVA analysis isolated the delay due to disruptions and explored that student might be delayed about 1.62 years for each year of war Six Sigma and a reduction in average graduation delay by 1 year for students with excellent supervisor availability compared to low. Moreover, 10 months years for students with excellent resources availability compared to low, This factor, though having a smaller impact than war interruptions and supervision, was also significant in improving graduation timelines.. These improvements were statistically significant, indicating the effectiveness of the Six Sigma approach in optimizing graduation time if the improvement plan is adopted by the decision makers in the higher education institutes.

5. DISCUSSION

The findings of this study demonstrate the potential of Six Sigma to enhance quality in higher education by optimizing graduation time. The significant improvements in student performance and reduced graduation time suggest that data-driven approaches can address key issues in educational processes. However, the success of Six Sigma initiatives depends on institutional commitment and continuous monitoring. The case study of Benghazi University highlights the critical factors that need to be addressed.

6. CONCLUSION

This study provided compelling evidence that Six Sigma can be a valuable tool for improving quality in higher education by optimizing graduation time. By systematically addressing performance issues and streamlining processes, institutions can achieve better academic outcomes and more efficient graduation timelines. As educational standards continue to evolve, the adoption of Six Sigma methodologies can help institutions stay competitive and meet the growing demands for quality education.

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