Using the SIX SIGMA Methodology to Improve the Quality of Educational Service: A Case Study in the Technical College of Management - Baghdad

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Keywords: Six Sigma, Quality of Educational Service, Administrative Technical College.

Abstract: The research aims at the possibility of applying (SIX SIGMA) in the field of higher education, specifically in the technical and administrative college, as the concept of (SIX SIGMA) when applied in the college, achieves several advantages, including improving performance, simplifying work procedures and improving quality levels in university stages, and the descriptive approach has been used Analytical, and the use of (SIX SIGMA) equations to determine the hexagonal diffraction levels, The most important results of this study were the level of six-six deviations for the scientific departments (the Department of Accounting Management Techniques and the Department of Business Management Techniques), as they came at (2.82, 2.68) SIGMA levels, respectively, as well as knowing the number of years required for improvement and reaching the level of (SIX SIGMA) in the event that the six diffraction methodology is applied in the college. As for the most important recommendations of this study, it is working to spread the culture of (SIX SIGMA) among the departments of the college and under the direct guidance of those in charge of managing its affairs and to emphasize the arrival of this concept and their understanding of the logic of improving the educational process in the college, starting from admission to graduation with an acceptable level of quality (knowledge and added skill), as well as applying the six-scattering methodology to all departments of the College of Administrative Technology and knowing the level of divergence to carry out the improvement process, as well as providing the necessary training for those in charge of the educational process in a way that enables them to acquire the required skill to match the ability of individuals to be able to apply the six-scattering methodology.

1 INTRODUCTION

Six Sigma is considered one of the most famous modern management concepts and contemporary approaches that emerged from quality management for measuring and managing quality assurance. It is based on the principle of achieving the best quality levels with the least possible deviation, thereby achieving multiple advantages for higher education institutions, improving the quality of university performance, standardizing work procedures, distributing tasks effectively, and achieving the satisfaction of students, the labor market, and society with the higher education services provided by universities. Hence, this research tests the possibility of applying Six Sigma to improve the quality of education performance, highlighting the most important means and strategies that can be followed in this field while emphasizing the importance of its successful application and its alignment and harmony with the spirit of the age and its requirements. These should ultimately be reflected in the educational outputs, which determine the level of quality of higher education.

The research problem is how to apply the Six Sigma methodology in the Technical Administrative College, Baghdad, to improve its outputs. The research is important for making continuous improvements in higher education, as universities today face many pressures to improve their performance and prepare their graduates according to the specifications required in the labor market. The current research seeks to measure the Six Sigma deviation of departments quantitatively according to the descriptive analytical approach to apply the Six Sigma methodology in higher education institutions. This research differed from previous cognitive efforts in addressing the measurement of deviation in this way and method. The research also aims to determine

the number of years required for improvement based on the average annual improvement rate decided by the college, based on its capabilities and under suitable conditions that allow it to choose the percentage it works according to. Moreover, previous research was exploratory, while the current research is an extrapolation of reality through quantitative data and equations to extract the Six Sigma level for the scientific departments in the Administrative Technical College - Baghdad. The research resulted in a deviation level of (2.82) Sigma for the Accounting Techniques Department, while the Business Administration Techniques Department had a deviation level of (2.68) Sigma.

2 RESEARCH METHODOLOGY

2.1 Research Problem

The Technical College of Management needs to constantly update and develop its services and needs to change its view of its outputs, not being content with quantity alone but with the quality of these outputs, especially since it is responsible for providing outputs (students) that represent the fabric of society and its basic foundation consisting of educated and cultured individuals. The higher the quality of the college's performance, the stronger and more effective its graduates will be in advancing and developing society. Therefore, from this perspective, we are researching the advanced approach to quality management, Six Sigma, and its application in the Technical Administrative College. Therefore, the following questions can be raised to express the research problem:

- How can the Six Sigma methodology be applied in the Technical Administrative College/Baghdad to improve its outputs?
- What is the Six Sigma level for the scientific departments (Business Administration Techniques Department and Accounting Techniques Department) in the research sample of the Technical Administrative College?
- How many years are required for improvement in the college?

The research aims to apply the following:

- Apply the Six Sigma methodology in the Technical College of Administration to improve outputs.
- Determine the Six Sigma level for the scientific departments (Business Administration Techniques Department and Accounting Techniques Department) and the research sample.
- Determine the years required to reduce deviations based on the average annual improvement rate.

2.2 Study Population and Sample

The study population consists of six scientific departments in the college. The sample was for the scientific departments (Department of Accounting Techniques and Department of Business Administration Techniques) for the academic year (2019-2018) morning studies for the first, second, third, and fourth academic years, specifically for preparing students who failed in the first and second rounds.

2.3 Previous Studies

This research aims to improve understanding of how SIX SIGMA can improve the educational process towards achieving quality at the University of Michigan, Flint, USA. The research followed a case study approach and utilized quantitative data. The results showed that the higher education process at the level of Three Sigma (3σ) requires significant improvement and that the primary goal of higher education is student success through high-quality education, as any student's failure can be considered a failure in the process [1]. This research aims to understand the development, benefits, and challenges of 6σ practices in academia. The research was conducted at Presidency University, Karnataka, India. Using quantitative data, the higher education process at Presidency University showed a level of (3.46σ), which requires great importance for improvement to reach the level of 6σ [2]. The study by [3] aimed to empirically investigate the possibility of applying and implementing Lean Six Sigma (LSS) in Higher Education Institutions (HEIs). LSS is considered one of the latest service quality practices that have proven successful in the manufacturing and service sectors. Based on the empirical investigation, the main findings confirmed that LSS is applicable in higher education institutions and can provide positive benefits for HEIs .

2.4 Statistical Methods Used in Data Analysis

To analyze the data and extract results, the statistical program SIX SIGMA Calculators - Westgard was used as the following:

1) The Defect Per Opportunity (DPO): It is the sum of defects for (n) defective units divided by the total number of units, meaning as in (1):

$$\text{DPO} = \text{No. of}\frac{\text{Defects}}{\text{No}}\text{. of Units}, \quad (1)$$

2) Defect Per Million Opportunity (DPMO): It is the defect in one opportunity multiplied by one million as:

$$\text{DPMO} = \text{DPO} \times 106, \quad (2)$$

3) Quality improvement level according to the (SIX SIGMA) vision, as in (3), which is [4]:

$$3.4 = \text{DPMO}(1 - \text{AAIR}). \quad (3)$$

Where, AAIR means Average Annual Improvement Rate. Table 1 shows the number of defects per million opportunities and the Sigma level [5]:

Table 1: Number of defects per million opportunities (DPMO) and sigma level.

DPMO	SIGMA	DPMO	SIGMA	DPMO	SIGMA
691.462	1	115.070	2.7	1.866	4.4
655.422	1.1	96.800	2.8	1.350	4.5
617.911	1.2	80.757	2.9	966	4.6
579.260	1.3	66.807	3	686	4.7
539.828	1.4	54.799	3.1	483	4.8
500.000	1.5	44.565	3.2	337	4.9
460.172	1.6	35.930	3.3	233	5
420.740	1.7	28.717	3.4	159	5.1
382.088	1.8	22.750	3.5	108	5.2
344.578	1.9	17.865	3.6	72	5.3
308.537	2	13.904	3.7	48	5.4
274.253	2.1	10.724	3.8	32	5.5
241.964	2.2	8.198	3.9	21	5.6
211.856	2.3	6.210	4	13	5.7
184.060	2.4	4.661	4.1	9	5.8
156.655	2.5	3.467	4.2	5	5.9
135.666	2.6	2.555	4.3	3.4	6

The vocabulary of the educational process was defined according to the Six Sigma methodology as follows:

- The student is considered one unit.
- All cases of non-success are considered a defective unit.
- The number of non-success cases in the academic stage divided by the number of students is considered the defect rate per unit.

3 FRAMEWORKS OF SIX SIGMA

3.1 Concept of Six Sigma Methodology

The concept of Six Sigma was first introduced by statistical experts at Motorola in the mid-1980s, led by engineer Bill Smith, to increase its competitiveness against Japanese companies in the electronics industry by improving quality levels. Over time, it evolved into a comprehensive approach to improving business performance. The key elements of Six Sigma methodology include a clear focus on customer needs, use of performance metrics, emphasis on improving business processes by reducing inherent process variation, using highly structured data-driven problem-solving methodologies, and ultimately generating tangible business results.

Six Sigma is an organized knowledge management methodology that focuses on reducing variation, measuring defects, and improving the quality of products, processes, and services. It is a statistical quality goal that equals less than (3.4) defects per million opportunities. Six Sigma has become a registered trademark of Motorola, an American company. The company aimed to keep the error rate at no more than (3.4) errors per million and reduce the number of defective units. It also aimed to save 5% of the production costs that were spent on repairing or disposing of defective units and to save (2.2) billion dollars over four years [5]. Six Sigma has been defined as an established approach that seeks to identify and eliminate defects, errors, or failures in business processes or systems by focusing on process performance characteristics that are of critical importance to customers [6].

3.2 Requirements for Successful Implementation of Six Sigma Methodology

To ensure the successful application of the Six Sigma methodology, the necessary components for this approach should be available. Many researchers have presented a set of criteria and requirements [7]-[9].

Top Management Support and Commitment: the conviction of top management in accomplishing a certain activity increases its value and gives it a higher weight compared to other activities. The Six Sigma approach is an important strategy that should

stem from the top of the organization and requires convincing and motivating employees at middle and lower management levels about the importance of change. Top management leaders must have enthusiasm and interest in applying the approach. Therefore, top management's support and commitment to implementing the approach is extremely important.

Feedback provides timely and continuous feedback on quality programs and their performance to employees and managers allows for process improvement, leading to higher quality levels. This contributes to increasing opportunities for success, innovation, and excellence for the organization. Feedback is defined as positive or negative reactions to system outputs. The quality of system outputs can be verified by comparing them to predetermined performance standards and then feeding the results of this comparison back into the system. The goal of the feedback process is to maintain the system's performance level and address deviations, contributing to the system reaching a state of balance and stability.

Human resources constitute the most vital element in implementing the Six Sigma approach in any organization by providing the necessary competencies. The skills that employees must acquire include training in process management, customer needs analysis, and statistical tools for dealing with problems. The Six Sigma approach is also linked to human resources by connecting promotion and incentive systems to the methodology. Training programs are based on employee experiences, with training programs applied to each level of expertise, and these levels are subject to the belt system.

3.3 Organizational Structure of the Six Sigma Methodology Team

Applying the Six Sigma methodology requires forming work teams and individuals with specific roles who carry belts that reflect their training and qualifications. The belt holders in Six Sigma indicate that Six Sigma cannot be viewed as merely the work of machines, materials, processes, and statistical methods but is equally the work of individuals trained and qualified with graduated knowledge and skills. Similar to how karate uses types of graduated belts (yellow, orange, green, up to black), it expresses the kind of progression in the roles of individuals in Six Sigma as follows [10]:

3.3.1 The Champion (Sponsor)

The Champion (Sponsor) represents the experienced leadership individual who works to provide the necessary resources for team members, including training, programs, and other requirements. It is responsible for creating the organization's vision, determine the methods and means to apply the Six Sigma methodology in the organization, participates in selecting Black Belt and Green Belt members [11].

3.3.2 Operation Leader

The role of the operation leader is centered on spreading the Six Sigma culture within the organization to perform the function of a professional coach in organizational development, determining the organization's readiness for development, defining the responsibilities of work teams and required activities [12].

3.3.3 The Master Black Belt

The role of the Master Black Belt is to work as a trainer and consultant for Black Belt holders, and support Black Belts in implementing Six Sigma. Master Black Belt candidates typically show interest in leading Six Sigma. Senior management selects candidates for leadership based on the organization's needs and the role of Six Sigma methodology in meeting those needs [13].

3.3.4 Black Belt

The Black Belt holder plays one of the important roles in Six Sigma as they are fully dedicated to address and solve problems and maintaining project continuity to achieve results, and directly responsible for the team and managing the team's work [14].

3.3.5 Green Belt

The Green Belt holder is one of the individuals trained in Six Sigma skills, often at a level similar to the Black Belt but with less extensive training. Their training typically lasts about two weeks and focuses on leadership skills and statistical methods. Their tasks include [15].

3.3.6 Yellow Belt

The Yellow Belt holder is typically the process executor, whether in the industrial or service field, and participates in the Six Sigma team by working with the Green Belt holder to identify and measure improvement opportunities within the local environment [16].

3.4 DMAIC Model

DMAIC is a Six Sigma model used for data-driven problem-solving and employed to improve an existing process. DMAIC deals with current processes that have failed and is an acronym for the first letters of five interconnected stages that work on continuous improvement of existing processes, which are [17]:

1) Define. This means identifying the problem or process.
2) Measure. This means measuring the problem or process.
3) Analyze. This means analyzing the data, identifying the root causes of defects, and determining the appropriate statistical methods to analyze the causes of the problem.
4) Improve. This is the stage of improving the process by finding solutions to fix and reduce deviations.
5) Control. This aims to ensure the success of the improvements made and the continuation of this approach in the long term.

3.5 The Concept of Educational Service Quality

The importance of services in an individual's life is increasing day by day, as they have become one of the important approaches in administrative and organizational practices. Interest in this field emerged in the 1990s with a focus on universities [18]. Educational service quality is an ongoing process that evolves over time, with universities having the opportunity for continuous improvement in serving the same customers (students), thus providing ample time for service providers to improve their level of service delivery. Higher education institutions have the opportunity to learn from their mistakes and exceed student expectations. Therefore, educational service quality is seen as a distinction among higher education institutions through their ability to create unique educational experiences. These experiences can be produced through a variety of means, including classroom teaching, extracurricular activities, supervision, administrative support, or leadership [19], [20].

Student satisfaction with educational services is one of the most important strategic factors for attracting students to higher education institutions and developing different models of education service quality to stimulate improvement actions [21]. The view of educational service quality should be comprehensive and meet the needs of students, parents, organizations, and society in general. Educational service quality has been defined as high-quality educational experiences provided by universities to their students to gain a competitive advantage [22]. As we observe in Table 3, the Business Administration department was at its best in the fourth stage, with more than 3 SIGMA, while it decreased to less than that for the first and third stages. The overall average for the department was more than 2 SIGMA.

4 THE PRACTICAL ASPECT

4.1 Extracting the Six Sigma Deviation for the Scientific Departments

Data on the number of participating students and the number of failing students (as defective units) were obtained and compiled in the following tables, and their results were analyzed and compared, as we noted in the Table 2, the Accounting Techniques Department was at its best in the second stage (3.35), while it decreased to less than that for the first and third stages due to the increase in the number of failing students for these two stages. The overall average for the department was more than (2 SIGMA). Table 3 shows the results of applying equations (1, 2, and 3) to students of the Business Administration Department using the Six Sigma Calculators Westgard program.

As we observe in Tables 3 and 5, the Busines Administration department was at its best in the fourth stage, with more than 3 SIGMA, while it decreased to less than that for the first and third stages. The overall average for the department was more than 2 SIGMA.

Table 2: Results of implementing Six Sigma according to the stages of the Accounting Department.

Year	# participating students	# failing students	Defect rate per unit	Defects per million DPMO	Six Sigma
First	180	19	0.10555	105556	2.75
Second	157	5	0.03184	31847	3.35
Third	128	23	0.17968	179687	2.42
Fourth	178	13	0.07303	73034	2.95
Sum	643	60	0.09331	93313	2.82

Table 3: Results of applying Six Sigma according to the stages of the Business Administration Department.

Year	# participating students	# failing students	Defect rate per unit	Defects per million DPMO	Six Sigma
First	203	49	0.24137	241379	2.20
Second	197	13	0.06599	65990	3.01
Third	124	9	0.07258	72581	2.96
Fourth	128	7	0.05468	54688	3.10
Sum	652	78	0.11963	119632	2.68

4.2 Measuring Quality Improvement Level According to SIX SIGMA Vision

The measurement of quality improvement level according to SIX SIGMA vision relies on the SIGMA rate and Defects Per Million Opportunities (DPMO) and demonstrates how to derive them through the above equations. It also depends on the average annual improvement rate percentage. This percentage is chosen based on the college's capabilities and its ability to impose a rate according to which it operates. These capabilities depend on (infrastructure, faculty members, financial capabilities, the extent of culture, and awareness of individuals working in the college about the benefits of applying this methodology). Accordingly, the college decides at what rate it can work to raise the level of Six Sigma and thus reduce deviations (number of failing students) to the maximum extent possible by knowing the level of deviation and the period it takes the college to improve based on the average annual improvement rate that the college decided to work according to the sigma results extracted from Table 2 for the Accounting Department for the year (2018-2019), it was found that the sigma rate for the department is (2.82) and that the DPMO is (93313). If we assume that the average annual improvement rate is (25%), how many years would it take the department to reach (SIX SIGMA)?

$$3.4 = 6 \text{ SIGMA},$$
$$93313 = 2.82 \text{ SIGMA}.$$

According to the quality improvement equation based on the SIGMA vision (3):

$$3.4 = 93313\ (1 - 0.25)^{X},$$
$$3.4 = 93313\ (0.75)^{X},$$

By dividing both sides by Log,

$$\log \frac{3.4}{93313} = \log \frac{93313\ (0.75)X}{93313},$$
$$\log \frac{3.4}{93313} = \log\ (0.75)x,$$
$$x = \frac{-4.438463235}{-0.124938736},$$
$$x = 35.5 \text{ year}.$$

From the above result, it appears that the number of years to reach Six Sigma is 35 years and 3 months, assuming an improvement rate of 25%. However, if we assume an average annual improvement rate of 50%, how many years would it take to reach Six Sigma?

$$3.4 = 6 \text{ SIGMA},$$
$$93313 = 2.82 \text{ SIGMA}.$$

According to the quality improvement equation based on the SIGMA vision (3)

$$3.4 = 93313\ (1 - 0.50)X,$$
$$3.4 = 93313\ (0.50)X$$

By dividing both sides by Log

$$\text{Log} \frac{3.4}{93313} = \log \frac{93313\ (0.50)X}{93313},$$
$$\log \frac{3.4}{93313} = \log(0.50)x,$$
$$X = \frac{-4.438463235}{-0.301029995},$$
$$X = 14.7 \text{ year}.$$

It turns out that when the average annual improvement rate is increased to 50%, the number of years to reach Six Sigma decreases, becoming 14 years and 7 months. Now, assuming the average

annual improvement rate for the accounting department is 75%, how many years will it take to reach Six Sigma?

$$3.4 = 6 \text{ SIGMA},$$
$$93313 = 2.82 \text{ SIGMA}.$$

According to the quality improvement equation based on the SIGMA vision (3)

$$3.4 = 93313 (1- 0.75)^{X},$$
$$3.4 = 93313 (0.25)^{X}.$$

By dividing both sides by Log

$$\text{Log } \frac{3.4}{93313} = \log \frac{93313 (0.25)X}{93313},$$
$$\log \frac{3.4}{93313} = \log (0.25)^{x},$$
$$X = \frac{-4.438463235}{-0.602059991},$$
$$X = 7.3 \text{ year}.$$

Based on the result obtained from applying (3), and assuming a percentage of 75%, the number of years to reach SIX SIGMA is (7) years and (3) months for the morning accounting department 2018-2019. According to the results of applying SIX SIGMA to the Business Administration department for the year (2018-2019) and assuming that the average annual improvement rate is (25%), how many years will it take to reach SIX SIGMA?

$$3.4 = 6 \text{ SIGMA},$$
$$119632 = 2.68 \text{ SIGMA}.$$

According to the quality improvement equation based on the SIGMA vision (3)

$$3.4 = 119632 (1- 0.25),$$
$$3.4 = 119632 (0.75),$$

By dividing both sides by Log

$$\text{Log } \frac{3.4}{119632} = \log \frac{119632 (0.75)x}{119632},$$
$$\text{Log } \frac{3.4}{119632} = \log (0.75)^{x},$$
$$X = \frac{-4.546368446}{-0.124938736},$$
$$X = 36.3 \text{ year}.$$

From the above result for the Business Administration department for the year (2019-2018), assuming that the average annual improvement rate is (25%), the number of years to reach (SIX SIGMA) is (36) years and (3) months. If the average annual improvement rate is raised to (50%), how many years will it take to reach the (SIX SIGMA) level?

$$3.4 = 6 \text{ SIGMA},$$
$$119632 = 2.68 \text{ SIGMA}.$$

According to the quality improvement equation based on the SIGMA vision (3)

$$3.4 = 93313 (1- 0.50)^{X},$$
$$3.4 = 93313 (0. 50)^{X}.$$

By dividing both sides by Log

$$\text{Log } \frac{3.4}{119632} = \log \frac{119632 (0.50)x}{119632}$$

$$\text{Log } \frac{3.4}{119632} = \log (0. 50)^{x}$$
$$X = \frac{-4.546368446}{-0.301029995}$$
$$X = 15.1 \text{ year}$$

It appears that the number of years required to reach Six Sigma is 15 years and 1 month for the Business Administration department if the college decides to work at 50% capacity under conditions suitable for that percentage. However, if we assume that the average annual improvement rate is 75%, how many years would be required to reach Six Sigma?

$$3.4 = 6 \text{ SIGMA},$$
$$119632 = 2.68 \text{ SIGMA}.$$

According to the quality improvement equation based on the SIGMA vision (3)

$$3.4 = 93313 (1- 0.75)^{X},$$
$$3.4 = 93313 (0.25)^{X},$$

By dividing both sides by Log

$$\text{Log } \frac{3.4}{119632} = \log \frac{119632 (0.25)x}{119632},$$
$$\text{Log } \frac{3.4}{119632} = \log (0. 25)x,$$
$$X = \frac{-4.546368446}{-0.602059991}, \quad X = 7.5 \text{ year}.$$

From the above result for the Business Administration department for the year (2019-2018), assuming that the average annual improvement rate is (75%), the number of years required to reach (SIX SIGMA) is (7) years and (5) months. From Table 4 and Table 5. briefly shows the assumed percentages and the number of years to reach Six Sigma

Table 4: Results Number of years of (SIX SIGMA) required for the Accounting Department.

Default rate	Years required to reach Six Sigma
%25	35.5
%50	14.7
%75	7.3

Table 5: Number of years required for the Business Administration Department to reach Six Sigma.

Default rate	Years required to reach Six Sigma
%25	36.3
%50	15.1
%75	7.5

5 CONCLUSIONS

The application of the Six Sigma methodology in the Administrative Technical College represents an important managerial advancement in improving the quality of educational services within the evolving higher education environment. It aligns with the need to continuously respond to students' expectations as primary recipients of educational services, thereby contributing to the enhancement of overall service quality within the college.

The results of the study indicate that the implementation level of Six Sigma in the Accounting Techniques Department reached 2.82 sigma, while the Business Administration Techniques Department achieved 2.68 sigma. These results reflect a generally moderate level of performance in both departments, with only a slight difference observed between them in favor of the Accounting Techniques Department. This indicates relatively similar operational conditions and quality levels across the two departments.

Furthermore, the analysis of annual performance improvement shows variation in the time required to reach higher Six Sigma levels depending on the average rate of annual improvement. This suggests that progress toward higher quality levels is achievable but depends strongly on the institution's capacity, resources, and commitment to continuous improvement strategies.

Based on these findings, the study recommends providing specialized training programs for academic and administrative staff to enhance their ability to effectively apply Six Sigma tools and methodologies. It is also recommended to extend the application of Six Sigma across all departments of the Technical College of Management and to systematically measure the Sigma level for each unit to ensure comprehensive quality monitoring.

Additionally, although various tools can be used within the DMAIC framework, priority should be given to the most widely adopted and effective ones to ensure practical implementation. Overall, continuous assessment and improvement of Sigma levels are expected to significantly contribute to enhancing the quality of educational services provided by the college.

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