

# **Improvement of Diabetes Awareness: Applying Six Sigma to Increase Teachers Awareness Regarding Diabetic Children in Primary Schools in Kuwait**

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## **Abstract**

Six Sigma DMAIC is a methodology used by business organizations to improve their processes by controlling and reducing variation. In this project, an attempt is made to apply and implement Six Sigma to increase teacher's awareness regarding diabetic children in primary schools. At first, a pilot test was conducted to identify and prove the existence of problem. The results revealed that 45% of teachers did not know the symptoms of hypoglycemia where 20% of them faced more than 6 cases of diabetic pupils in the schools. Voice of the Customer (VOC) was then gained through a parent survey. The Critical to Quality (CTQ) was then identified as well as the Define Phase was then completed. Moreover, the teacher's current performance level was measured by distributing a knowledge test and the results discovered that the performance level is 57.7%. Therefore, the team decided to focus on increasing teacher's awareness by at least 30%. Several tools such as Quality Function Deployment (QFD) and Failure Mode Effect Analysis (FMEA) were implemented in both the Analyze and Measure phases, then the most effective improvements were identified. An educational awareness program was then conducted to introduce teachers to the most important information required to handle a diabetic child. Subsequently, another knowledge test was distributed to identify the improvements in the scores of the teachers. The results, revealed that the awareness level increased from 57.7% to 89.9%, and DPMO reduced from 476190 to 238095. Finally, the Control Phase was completed through introducing an action plan that would maintain the improvements made for more years to come.

## **Keywords**

Diabetes, Six Sigma, DMAIC, Quality Function Deployment, Failure Mode Effect Analysis, Critical to Quality, Response Action Plan

## **1. Introduction**

Our job as engineers is to ensure the safety of the children by implementing our knowledge learned in the past few years studying engineering into the project like Probability and Statistics in Engineering, Work Analysis and Design II, Quality Control, and Six Sigma and Quality Management). The methodology of six-sigma is contributed greatly to our project as we aim to increase teacher's knowledge regarding the diabetic children. Children's parents were the voice of customer that will be gained throughout the project by using the survey and a knowledge test for teachers. Finally, going through the five phases of DMAIC; the group members were able to find the most appropriate solution in order to maintain a well-oriented school atmosphere. As the school atmosphere supports the children's condition the rest of the project goals will fall into place.

## **2. Background**

Six-sigma is a well-known approach used to reduce the variations in the Voice of customer and the voice of Process. Six Sigma aims to eliminate the defects in a certain process to successfully reach the customers' expectations. By the time a six-sigma project is developed there will exist approximately zero defects 0.0000008. Bill Smith, at 1984, a Motorola engineer created and developed six sigma management systems to decrease the variation in the company's electronic manufacturing processes for him to be able to eliminate or decrease the number of defects that occur in their products. Since then six-sigma became one of the best approaches any company would seek to in order for it to improve its system or products (Rouse & McLaughlin, 2007).

Diabetes is a common life-long term health condition where the amount of glucose in the blood is not stable depending on the patient condition. Children at ages under twelve with diabetes need adults who are able to take care of them and help them in order to meet their treatment either at home or at school. There exist three different types of diabetes. Diabetic patients can be either type-one diabetes or type-two diabetes. Type-I diabetes is an autoimmune disease that attacks the pancreas and destroys the beta cells; therefore the body will stop producing insulin forever. However, type-II is the most common type of diabetes in which the pancreas does produce insulin, yet the body fails to use it properly. In addition, hypoglycemia and hyperglycemia are two main effects of diabetes both have different symptoms and can occur at any time during the day. Hypoglycemia happens when glucose levels are too low. On the other hand, hyperglycemia is high blood sugar, it happens when the body cannot use the insulin in the blood. (Osborn, 2017).

### **3. Literature Review**

Many papers were reviewed about diabetes and its types. Additionally, Six Sigma with has been successfully implemented in different sectors and has been accomplished in many projects. The project team reviewed many papers that implement Six Sigma with DMAIC phases by covering 3 sectors of Six Sigma which are manufacturing sector, health sector, and Six Sigma in service sector.

Brorsson, Viklund, Ortqvist, and Olinder in 2014, started their work by investigating the long-range effects on the "glycaemia" at the end of the study for the CSII shows an improvement in HbA1c after 6 and 12 months compared it with the BMI group, and decreased the number of severe hypoglycemic events, but the frequency of ketoacidosis increased (Brorsson, Viklund, Ortqvist & Olinder, 2015). Furthermore, different engineers used six-sigma to measure the relationship between diabetes and some other factors such as habitual sleep. As a result, the researcher found that "there was a significant difference between T2DM and healthy controls in nocturnal sleep duration ( $p=0.033$ ) and no significant difference in daytime sleepiness and daytime naps between the T2DM and control groups ( $p=0.452$ ;  $p=0.581$ , respectively)" (Al-Abri, Jaju, Al-Sinani, Al-Mamari, Albarwani, Al-Resadi, Bayoumi, Hassan, & Al-Hashmi, 2016). Another case reviewed and explains self-care practices among people with type-two diabetes in Addis Ababa. According to Wahido and Berhane (2017); "patients generally lack proper information/knowledge regarding the importance of self-care and how it should be implemented" (p.1).

Six Sigma with DMAIC method was applied to reduce the rejection rate of the engine mounting bracket (EMB) by reducing the defects in the process. According to Kaushik (2011), "Six-sigma within small- and medium-sized enterprises (SMEs) is rapidly emerging as the new wave of change in six-sigma" (p.107). As a result sigma level increased to 5.24 with a DPMO level of 0.08. Moreover, Dhiraj and Deepak aimed to decrease the product scrap in the position manufacturing organization. The scrap reduction decrease from 9.9% to 5%, DPMO from 99,000 to 50,000. Furthermore, "the sigma level was improved from 2.86 to 3.2 and the yield was improved from 90.1% to 95%" (Dhiraj.K& Deepak.K, 2015).

Six Sigma was used in different ways and different companies to produce a better yet qualified service that will satisfy the customer. Al Muhareb and Graham-Jones apply six sigma in King Khaled International Airport to improve the quality of service. As results "The KKIA is operated in a high and important sector as it is constantly active while there are several businesses and services that work through its care" (Al Muhareb&Graham-Jones, 2014). Furthermore, six sigma applied in the bank to improve the banking service, the authors found that the service cost more than parches cost, by improving the speed of service quality the results "they eliminate waste of waiting time for opening an account, modifies business cultures and creates the infrastructure to initiate and sustain greater performance and profitability" (Fu-Kwun, & Kao-Shan,2010).

A case study from the King Fahad University Hospital, Saudi Arabia was reviewed. The goal was fixed as to reduce medication errors in an outpatient pharmacy by 20%. (Al Kuwaiti, 2016, p.267). They reached "the Medication not properly labeled the sigma level change from 3.35 to be 4.08 and PPM change from 32,000 to 5,000 (Al Kuwaiti, 2016). Another authors used to improving a hospital discharge process. They reached results which are reducing the discharge average time from 3.3 to 2.8 h and "missing chart data was reduced by 62%, when prescriptions of debatable relevance were not included, a 79% reduction" (Allen.T, Tseng.S, Swanson.K& McClay. M, 2010, p.19).

### **4. Objective of the Study**

The objective of the study is improving the teacher's awareness level by 30%. By improving the teacher's amount of awareness the satisfaction of the parents, will be gained successfully and the project will accomplish its goal. The children will be provided by a safe environment during school hours and parents will be able to settle down and believe that their children are within safe hands. The teachers will have efficient knowledge to handle any situation that the diabetic child would suffer from and will be have the ability to respond in an accurate way.

## 5. DMAIC Methodology Implementation

### A. Define Phase

Today the numbers of diabetic children have increased in Kuwait, yet schools are considered to be any diabetic child parent's fear. The problem is that teachers are not properly aware of the diabetes condition and how to respond accurately to an incident in which a student suffers from a hypoglycemic attack. Therefore, 35% of children are affected by diabetes in Kuwait, according to Dr. Kazem Behbahani (Albasha, 2014).

The define phase consist of Project Charter, Collecting Voice of Customers (VOC), Identifying the Critical to Quality (CTQ) and Process Mapping.

#### ❖ Problem Statement

The project team created a pilot study to accurately identify the problem statement. The pilot test distributed among primary schools teachers in Kuwait and it proved that 55% of teachers were not aware of the symptoms of diabetes while 20% of teachers faced at least 6 cases of emergency diabetic emergency cases. However, 14% of teachers take no action towards a child that suffers from an emergency reaction due to diabetes. On the other hand, 43% of teachers simply call the nurse and leave the child suffer until the nurse arrives. Teachers are not acknowledged about the procedure and principles of handling a diabetic student. If we ignore this problem; the health of student's that suffer from diabetes will be affected negatively.

#### ❖ Project Charter

The project charter is a document that contains a summary of the most important information about the project. The project charter helps the project team to introduce the project vision and objectives. As well as, it contributes greatly to providing the organizational structure for the project as it shown in [Table 1].

Table 1: Project Charter

| Project Charter  |               |                |  |                |                |
|--|---------------|----------------|--|----------------|----------------|
| <b>Project Title:</b> Applying Six Sigma to Increases teacher Awareness Regarding to Diabetic children in Primary Schools                                  |               |                |  |                |                |
| <b>Problem statement</b>   |               |                | <b>Project Team</b>  |                |                |
| In kuwait 35 % of children suffered from type-I diabetes   |               |                | Shaikha AlDaboos, Industrial Engineering Student<br>Layali Al Dhefeeri , Industrial Engineering Student<br>Fatimah Al Juhaime, Industrial Engineering Student<br>Rawan Al Shatti, Industrial Engineering Student<br>Alaa Khalaf, Industrial Engineering Student  |                |                |
| <b>Objective</b>   |               |                | <b>Support Personels</b>   |                |                |
| Project Objective focuses on increasing the knowledge of teachers regarding diabetic children by 30%   |               |                | Mohammad Al-Bahar: Diabetes Type I motivator<br>Mohammad Al-Jeemaz: Professor in Six Sigma<br>Baraka Bint Yassar Primary School<br>Miss. Wafaa AlShammaeri, Principal Assistant<br>Dar Al-Shifa hospital: Clinical Dietitian Rasha Barkoni<br>Diabetes Parents<br>Dasman Diabetes Institute<br>Kuwait Diabetes Society<br>Kuwait Blue Circle |                |                |
| <b>Project Scope</b>   |               |                | <b>Project Leader</b>  |                |                |
| Project scope focuses on teachers in primary schools in Kuwait. The project aims to increase the amount of teachers awareness regarding diabetic children. |               |                | Dr.Walid Smew  |                |                |
| <b>Approaches</b>  |               |                | <b>Estimate Completion Date</b>  |                |                |
| Six Sigma ( DMAIC)   |               |                | 31/12/2017   |                |                |
| <b>Starting Date</b>   |               |                | <b>Estimate Completion Date</b>  |                |                |
| 5/2/2017   |               |                | 31/12/2017   |                |                |
| Project Milestones   | <b>1</b>      | <b>2</b>       | <b>3</b>   | <b>4</b>       | <b>5</b>       |
| Description :  | <b>Define</b> | <b>Measure</b> | <b>Analyze</b>   | <b>Improve</b> | <b>Control</b> |
| Date   | 10/4/2017     | 19/9/2017      | 23/10/2017   | 1/11/2017      | 16/12/2017     |

### ❖ Collecting of the VOC

Our customers are parents of diabetic children. The VOC was collected by distributing a survey questionnaire among parents of diabetic children. The purpose of the survey is to identify the needs of parents from teachers and what leads to their satisfaction and happiness. Parent's survey is used to illustrate the parents' needs and their priorities that they want from teachers towards their children. The survey basically included different statements and the parents were asked to choose the most important priority by using a scale (H: High, M: Moderate, L: Low). Pareto chart was constructed by listing the high priority and by counting the number of (H) in the priority list as it shown in [Figure 1]. The statements included in the survey were like:

- **S1:** Having background about diabetes.
- **S2:** Teacher's reaction during hypoglycemia.
- **S3:** Allowing diabetic pupil to participate in school activities.
- **S4:** Teachers should be prepared in providing student with reliable support and supervise.
- **S5:** Be able to identify diabetic pupil.
- **S6:** Insure pupil eat all their meals specially lunch and snacks.
- **S7:** Able to aware and understand the emergency cases according to glucose level.
- **S8:** Keeping records for parents.
- **S9:** If the pupil suffered from hypoglycemia during exam they should give him/her extra time to be able to complete the exam.
- **S10:** Allow pupil to access the bathroom and water if necessary.
- **S11:** Escorting the diabetic pupil to the bathroom.

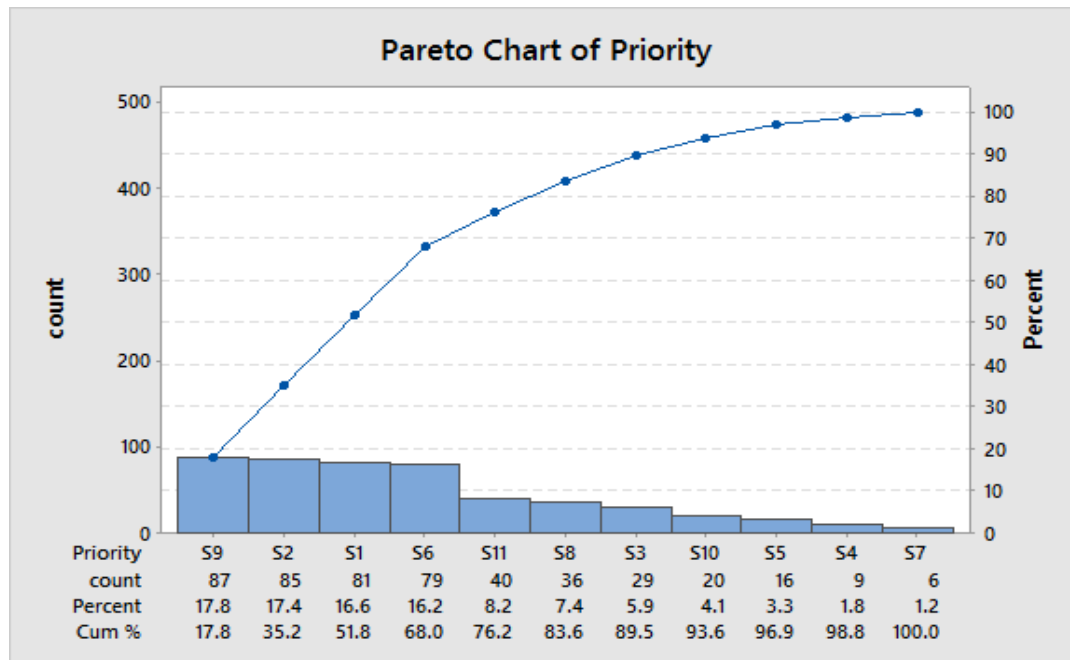


Figure 1: Pareto Chart

### ❖ Identifying Critical to Quality Characteristics (CTQ)

After collecting the VOC these characteristics will be used in quality function deployment to apply the improvement by translating them into attributes in the analyze phase. According to this project by satisfying and accomplishing the most important statements the team will be able to solve 80% of the problem by focusing on the following:

- S9:** If the pupil suffered from hypoglycemia during exam they should give him/her extra time to be able to complete the exam.
- S2:** Teacher's reaction during hypoglycemia.
- S1:** Having background about diabetes.
- S6:** Insure pupil eat all their meals specially lunch and snacks.
- S11:** Escorting the diabetic pupil to the bathroom.

## ❖ Process Mapping

A process map describes the entire process that a certain object or individual being studied goes through. [Figure 2], is a graphic process map that allow to understanding the current teacher reaction during a hypoglycaemia attack. At first, the student attends school in the morning and then the student is also required to stand in the schools' assembly line. After that, the students attend his classes. During the classes, if the students have hypoglycaemia attack, the teacher will take action. The teacher either takes unplanned random action such as giving him pieces of chocolate or calling the ambulance or calling the nurse. The un planned and random action may affect the child's health negatively. Calling the ambulance might take a long time till it arrives at the school. The best solution of these three reactions was calling the nurse to check the glucose level.

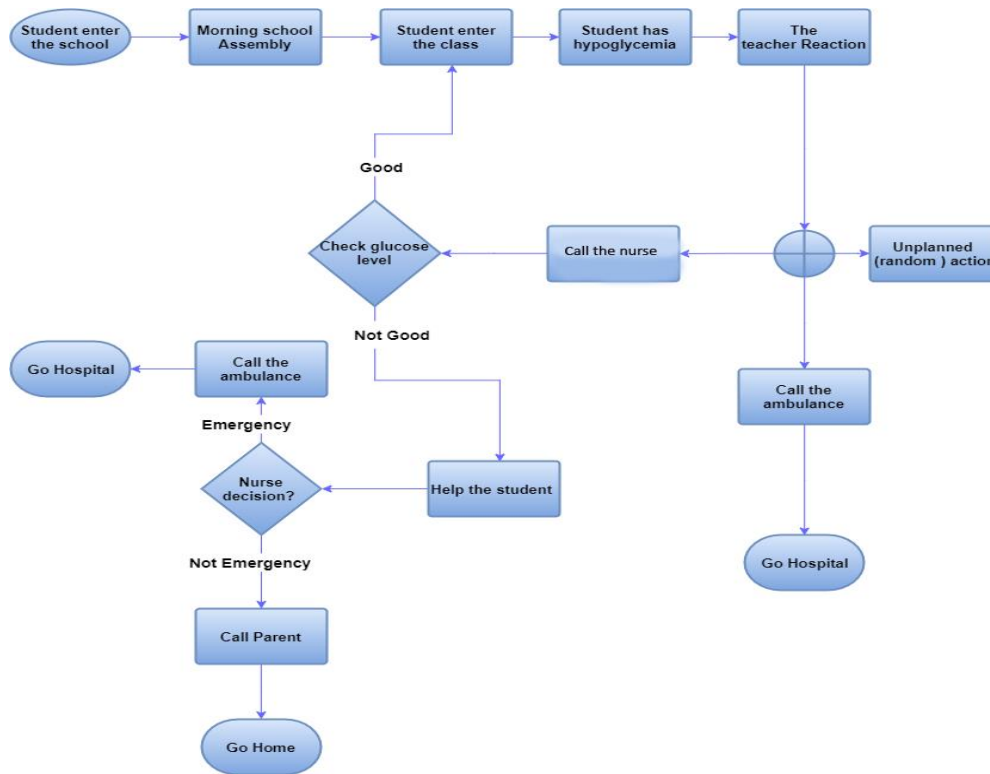


Figure 2: Process Map of current teacher's reactions

## B. Measure Phase

The measure phase was conducted to identify the current amount of knowledge the teachers have. Therefore, a knowledge test was directed and distributed among teachers in primary schools. The baseline evaluation was then determined to identify the current sigma level.

## ❖ Teacher Knowledge Test

The teacher's knowledge test was established based on the results of parents survey which was conducted in the define phase. It contains eleven questions that translate parent's priorities. Some of the equations are:

- What is diabetes?
- What are the symptoms of diabetes?
- What is the cause if the hypoglycemia?

The test was distributed between teachers in Baraka Bint Yassar girl's primary school. The scores were then conducted by the team members that corrected the tests. [Figure 3], shows the results of the scores obtained where the trend line in red colour

represents the mean average score. On the other hand, the green and blue bars are the teachers' test score. The test that scored below 57.7 % represents the defects of the test; because they are below the average score.

[Figure 4], displays the summary report for the test scores obtained as histogram then created along with the curve that is fixed to it, which exist no outliers in the box plot. Furthermore, p-value is equal to 0.115, which is above 0.08. The results indicate that the scores are normally distributed (for 92% confidence interval) and through that the team will complete the evaluation of the current process. As conclusion, the mean average awareness level of the teachers is equal to 57.7 %.

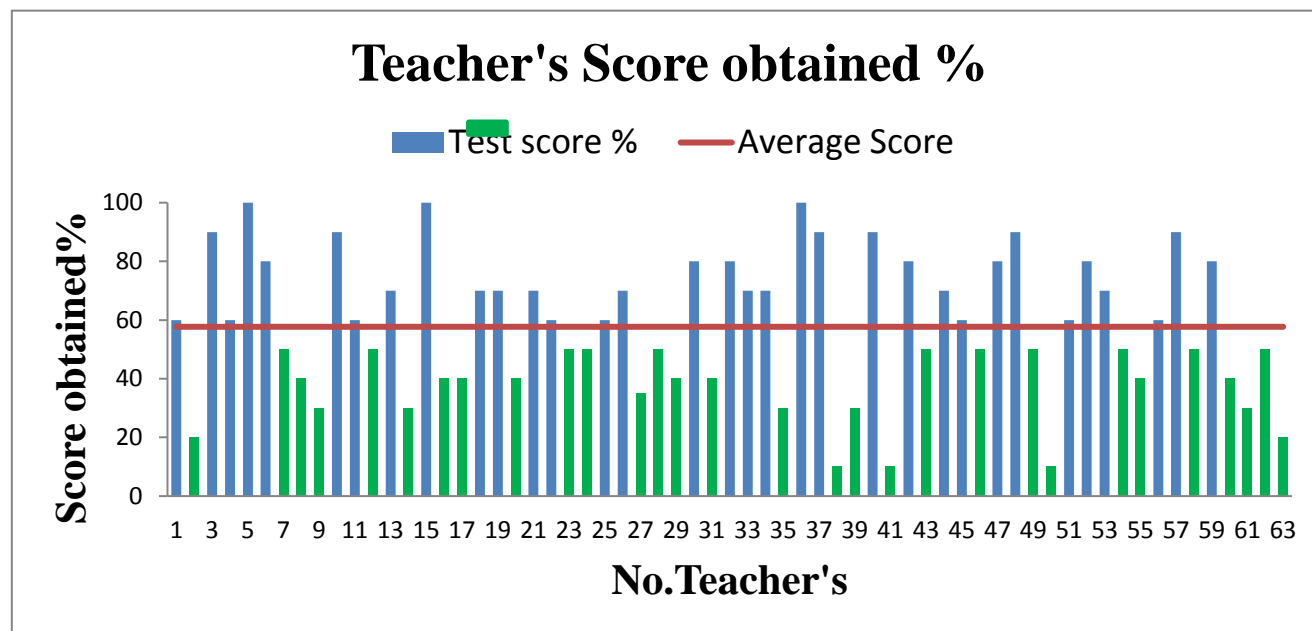


Figure 3: plot of score obtained vs. Teacher. No

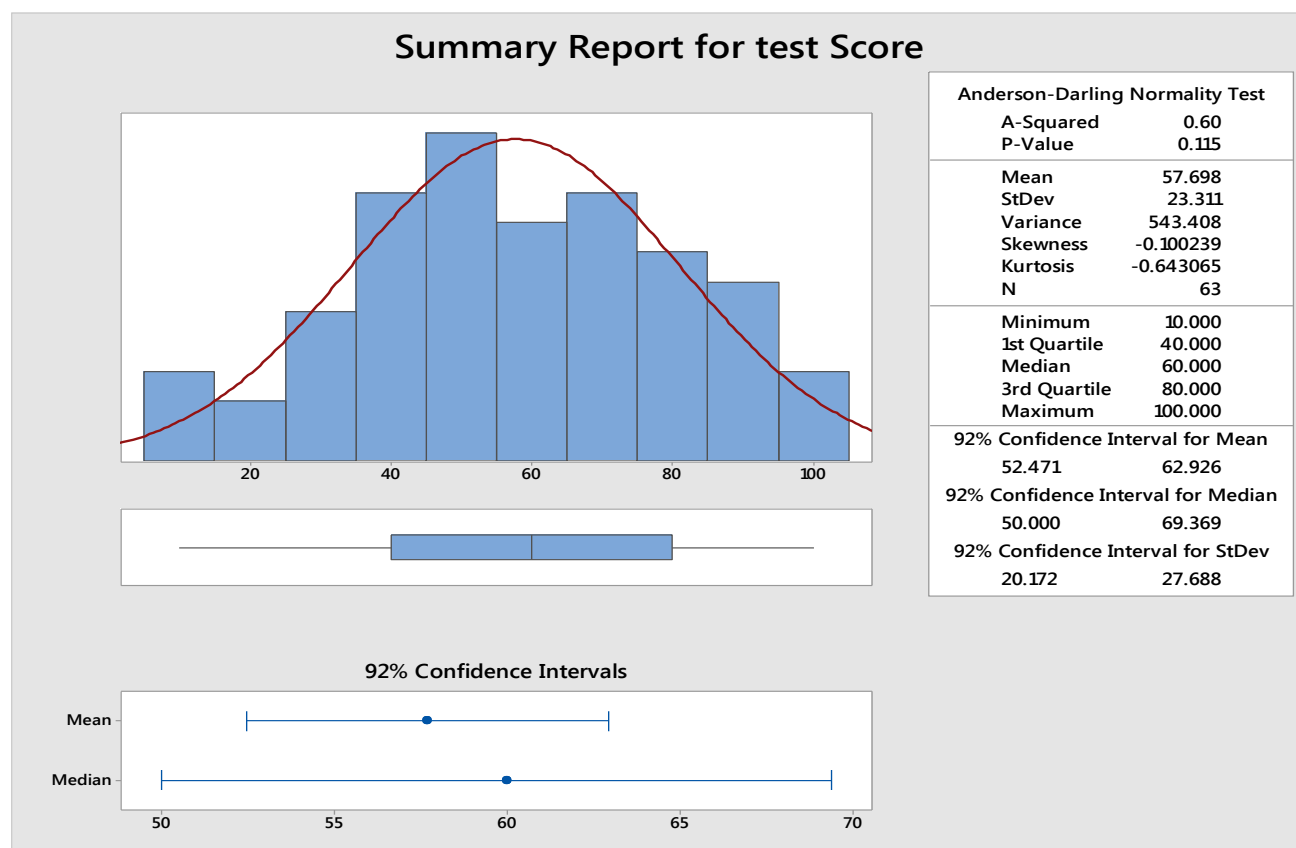


Figure 4: Score Report Summary

### ❖ **Baseline Evaluation**

The calculations of the baseline evaluation in terms of the current measurement of teacher's awareness are gained as follows:

- **Total number of teachers surveyed (o- opportunities) = 63**
- **Average test Score = 57.698**
- **Number of scores on or above the average score (c) = 33**
- **Number of scores below the average score (d-defects) = 30**
- **DPO (d /o) = (30/63) = 0.476190**
- **DPMO = (d/o)\*1000000 = 476190**
- **Yield %= 52.38%**
- **For the calculated DPMO, the current Sigma Rating = 1.55**

### **C. Analyze Phase**

Through the analyze phase the project team analyzed the results gained from the teacher knowledge test. Failure Mode Effect Analysis was then used to determine the risks associated with the possible improvements. Moreover, Quality Function Deployment first level was used to evaluate the critical to quality points and to find the most effective improvement that could be made.

### ❖ **Quality Function Deployment (QFD) First Level**

QFD is helping the team to identify customer requirements, parents, in order for the project team meet their needs and gain their satisfaction. The customer needs are identified in the define phase as CTQs to represent as (What's: Y- axis) and they are translated into specific plans to produce a well oriented process of teacher's reaction towards hypoglycaemic pupil represents in (How's: X-axis). [Figure 5], represent quality function deployment first level. The (How's: X-axis) are defined after brainstorming session with team and stakeholders to be able to reach parent satisfaction. The points are demonstrated below:

- Monitor food of diabetic pupil.
- Guide books introduce ways and actions that need to be taken.
- Diabetes workshops for pupil.
- Create parent committee.
- Teacher's workshops.
- Events and carnivals celebrating the world diabetes day.
- Introducing healthy meals to the cafeteria.
- Psychological support.
- Insure diabetic pupil wearing identification card.

### ❖ **Failure Mode Effect Analysis (FMEA)**

FMEA is used to focuses on the failure that might happen in the future and detect the risk by calculating Risk Priority Number (RPN). Failures are defined as the most important and highest priorities which are identified through QFD first level. The highest priorities are the ones with the highest total therefore;

- **Teachers reaction towards hypoglycemia = 185**
- **Having a background about diabetes = 135**

The severity was then selected in a scale of 1 to 10 where 1 represents the lowest severity, and 10 represent the highest severity. The occurrence was then selected in also a scale of 1 to10 where 1 represents the occurrence severity, and 10 represent the highest occurrence. The Detectability rate was then identified with 1 being the highest while 10 is considered as the lowest detectability. [Figure 6]; represent the FMEA of the process.



| Process Requirement (How's)  |            |                                   |  |                              |                        |                   |   |  |                       |  |       |
|--|------------|-----------------------------------|--|------------------------------|------------------------|-------------------|---|--|-----------------------|--|-------|
| Customer Expectation (What's)  | Importance | Monitor food of diabetes children | Guid book introduce ways and actions that need to be taken | Diabetes workshop for pupils | Great parent committee | Teachers Workshop | Events and carnivals celebrating the world diabetes day | Introducing healthy meals to the cafeteria | Psychological support | Insure diabetic pupils wearing identification card | Total |
| Having background about diabetes.  | 5          |                                   | H  |                              | M                      | H                 |   | L  |                       |  | 135   |
| Teacher's reaction during hypoglycemia.  | 5          |                                   | H  |                              |                        | H                 |   |  | H                     | M  | 185   |
| Allowing diabetic pupil to participate in school activities.   | 3          |                                   |  | H                            | M                      |                   | M   |  | H                     | H  | 123   |
| Teachers should be prepared in providing student with reliable hands-on support and supervise.                           | 3          |                                   |  |                              | M                      | H                 |   |  | H                     |  | 78    |
| Be able to identify diabetic pupils  | 3          |                                   |  |                              |                        |                   |   |  |                       | H  | 33    |
| Insure diabetic pupils eat all their meals specially lunch and snacks.   | 5          | H                                 |  |                              |                        |                   |   | M  |                       |  | 75    |
| Able to aware and understand the emergency cases according to glucose level.   | 1          |                                   | M  |                              |                        | H                 |   |  |                       | M  | 19    |
| Keep records for parents   | 3          |                                   |  |                              |                        |                   |   |  | M                     |  | 12    |
| If the pupil suffered from hypoglycemia during exam they should give him/her extra time to be able to complete the exam. | 5          |                                   |  |                              |                        |                   |   |  |                       | H  | 55    |
| Allow pupil to access the bathroom and water if necessary.   | 3          |                                   | H  |                              |                        |                   |   |  |                       | H  | 66    |
| Escorting the diabetic pupil to the bathroom.  | 1          |                                   |  |                              |                        |                   |   |  |                       | M  | 4     |
| <b>Total</b>   |            | 55                                | 147  | 33                           | 44                     | 154               | 12  | 25   | 133                   | 182  | 785   |
| <b>Relative Weight (Priority)</b>  |            | 7.01%                             | 18.73%   | 4.20%                        | 5.61%                  | 19.62%            | 1.53%   | 3.18%                                      | 16.94%                | 23.18%   |       |

Figure 5: Quality Function Deployment first level

The relationship matrix represents the following:

- **H:** High relationship between customer expectation and process requirement. (H=11)
- **M :** Medium relationship between customer expectation and process requirement.( M=4)
- **L:** Low relationship between customer expectation and process requirement. (L=1)

The results show that the highest priority of process requirements gained the highest percentage of the relative weight which is 23.18% and represents insuring diabetic students wear an identification card. While on the other hand, the teacher's workshop has a relative weight of 19.62%.

#### D. Improve Phase

The improve phase is used to list all the potential solutions to meet the process improvement. QFD second level, FMEA for improvement, update baseline evaluation and improvement implementation (process map) were used.

#### ❖ QFD Second Level

Quality function deployment second level is created it to meet the process needs for implementing improvements of the process which are represented in [Figure 7]. The process needs represent in (What's X-axis), and the (How's Y-axis) represent the process requirements to implement the improvements and they are the following:

- Provide supervisor to a group of diabetic pupils
- An assembly in which a diabetes professional familiarize individual about diabetes and how to deal with emergency cases.



- Involve diabetes organizations in school exciting events and create pupil activities
- Adding a selection of fruits and vegetables to the cafeteria.
- Schools provide life coach that will meet with diabetic pupils and enhance their personality.

The result shows that the most effective statement on the system improvement is “An assembly in which a diabetes professional familiarize individual about diabetes and how to deal with emergency cases”. It represents 40.96% of achieving process improvements to meet parent’s expectations.

| Process Step             | Potential Failure Mode       | Potential Failure Effect  | SEV | Potential Causes  | OCC | Current Control  | DET | RPN |
|--------------------------|------------------------------|---|-----|---|-----|--|-----|-----|
| Teacher Reactions        | No Background about Diabetes | Cannot recognize emergency  | 9   | Don't attend workshop   | 8   | Keep attendance record, that affect their accreditation  | 5   | 360 |
|                          |                              |   |     | No concentration in workshop  | 7   | None   | 4   | 252 |
|                          |                              | Pupil health deterioration  | 10  | Pupil long-time unconscious   | 10  | Never leave pupil without action                         | 3   | 300 |
|                          |                              |   |     | Teacher take risky and wrong action                                       | 10  | Don't take actions and call nurse immediately            | 2   | 200 |
| Identify Diabetic pupils | No ID card                   | Teacher fail to monitor pupil food                                    | 8   | Teacher is irresponsible  | 10  | Parents insure pupil have their appropriate daily meals  | 2   | 160 |
|                          |                              | If hypoglycaemia attack occurs, teacher fail to identify medical case | 10  | The symptoms are not clear  | 9   | Teachers doesn't take action until medical case is clear | 2   | 180 |
|                          |                              | Pupil participating in exhausting activities                          | 7   | Teacher not aware of student medical condition                            | 10  | If pupil is feel tired let allow them to take a rest     | 2   | 140 |
|                          |                              | Not provided pupil needs ( eating, drinking, and entering bathroom)   | 9   | Teacher identify student actions as being careless and want to waste time | 6   | Ask pupil of necessity of going to the bathroom          | 1   | 54  |
|                          |                              |   |     |   |     | Identify the pupil reason of eating                      | 2   | 108 |

Figure 6: Failure Mode Effect Analysis

| X's (How's)   |            |  |  |  |  |   |       |
|---|------------|--|--|--|--|---|-------|
| Process Requirement Y's (What's)                              | Importance | Provide supervisor to a group of diabetic pupils | An assembly in which a diabetes professional familiarize individual about diabetes and how to deal with emergency cases. | Involve diabetes organizations in school exciting events and create pupil activities | Adding a selection of fruits and vegetables to the cafeteria | Schools provide life coach that will meet with diabetic pupils and enhance their personality. | Total |
| Monitor food of diabetic pupil                                | 1          | H  |  |  | H  |   | 22    |
| Guide books introduce ways and actions that need to be taken. | 5          |  | H  |  |  |   | 55    |
| Diabetes workshops for pupil                                  | 1          |  | H  | M  |  | H   | 26    |
| Create parent committee.                                      | 3          |  | M  | M  |  |   | 24    |
| Teacher's workshops.  | 5          |  | H  | M  |  |   | 75    |
| Events and carnivals celebrating the world diabetes day.      | 1          |  |  | H  |  |   | 11    |
| Introducing healthy meals to the cafeteria.                   | 3          |  |  |  | H  |   | 33    |
| Psychological support.  | 3          |  | M  |  |  | H   | 45    |
| Insure diabetic pupils wearing identification card.           | 5          | H  |  |  |  |   | 55    |
| Total   |            | 66   | 145  | 55   | 44   | 44  | 354   |
| Relative Weight (Priority)                                    |            | 18.64%   | 40.96%   | 15.54%   | 12.43%   | 12.43%  |       |

Figure 7: Quality Function Deployment second level

## ❖ FMEA (improvement)

Failure mode effect analyses for the improve phase is created to reduce the risk priority numbers based on the recommended actions and to detect any potential failures. By detecting those failures the project team will be able to eliminate the failures by creating recommended actions to avoid them. [Figure 8], represent the FMEA and the results show that the “RPN” of teacher’s reactions was 360 and it reduced to be 135 if the teachers and schools follow the actions recommended in the exact way. Moreover, identify diabetic student “RPN” decreased to 50 if the school provide supervisors to take care of individual diabetic student.

|                          |                              |   |     |   |     |  |     |     |   |                    |     |     |     | Improvement |  |  |  |
|--------------------------|------------------------------|---|-----|---|-----|--|-----|-----|---|--------------------|-----|-----|-----|-------------|--|--|--|
| Process Step             | Potential Failure Mode       | Potential Failure Effect  | SEV | Potential Causes  | OCC | Current Control  | DET | RPN | Action Recommended  | Responsibility     | SEV | OCC | DET | RPN         |  |  |  |
| Teacher Reactions        | No Background about Diabetes | Cannot recognize emergency  | 9   | Don't attend workshop   | 8   | Keep attendance record, that affect their accreditation  | 5   | 360 | Guide books get delivered to the non-attendee                           | School Principle   | 9   | 3   | 5   | 135         |  |  |  |
|                          |                              |   |     | No concentration in workshop  | 7   | None   | 4   | 252 | Involve physical activities   | Workshop Organizer | 9   | 3   | 4   | 108         |  |  |  |
|                          |                              | Pupil health deterioration  | 10  | Pupil long-time unconscious   | 10  | Never leave pupil without action                         | 3   | 300 | Take action and call nurse and ambulance                                | Teacher            | 10  | 3   | 3   | 90          |  |  |  |
|                          |                              |   |     | Teacher take risky and wrong action                                       | 10  | Don't take actions and call nurse immediately            | 2   | 200 | Insure the teacher attends next workshop                                | School Principle   | 10  | 4   | 2   | 80          |  |  |  |
| Identify Diabetic pupils | No ID card                   | Teacher fail to monitor pupil food                                    | 8   | Teacher is irresponsible  | 10  | Parents insure pupil have their appropriate daily meals  | 2   | 160 | Assign a responsible supervisor to guide and monitor the diabetic pupil | Supervisor         | 10  | 5   | 1   | 50          |  |  |  |
|                          |                              | If hypoglycaemia attack occurs, teacher fail to identify medical case | 10  | The symptoms are not clear  | 9   | Teachers doesn't take action until medical case is clear | 2   | 180 |   |                    |     |     |     |             |  |  |  |
|                          |                              | Pupil participating in exhausting activities                          | 7   | Teacher not aware of student medical condition                            | 10  | If pupil is feel tired let allow them to take a rest     | 2   | 140 |   |                    |     |     |     |             |  |  |  |
|                          |                              | Not provided pupil needs ( eating, drinking, and entering bathroom)   | 9   | Teacher identify student actions as being careless and want to waste time | 6   | Ask pupil of necessity of going to the bathroom          | 1   | 54  |   |                    |     |     |     |             |  |  |  |
|                          |                              |   |     |   |     | Identify the pupil reason of eating                      | 2   | 108 |   |                    |     |     |     |             |  |  |  |

Figure 8: Failure Mode Effect Analyses (Improvement)

## ❖ Teachers Knowledge Test

The team conducted an educational awareness program for 3 days with Dar Al-Sheffah Hospital in Baraka Bint Yassar girl's primary school. The program was about diabetes, hypoglycemia attacks, correct action toward hypoglycemia, and how to deal with diabetic pupils. The same test was distributed between teachers. [Figure 9], represents the results test scored after the program, the green bars are the defects and the blue bars are the opportunities the mean average is in red bar which increased to 89.9 %.

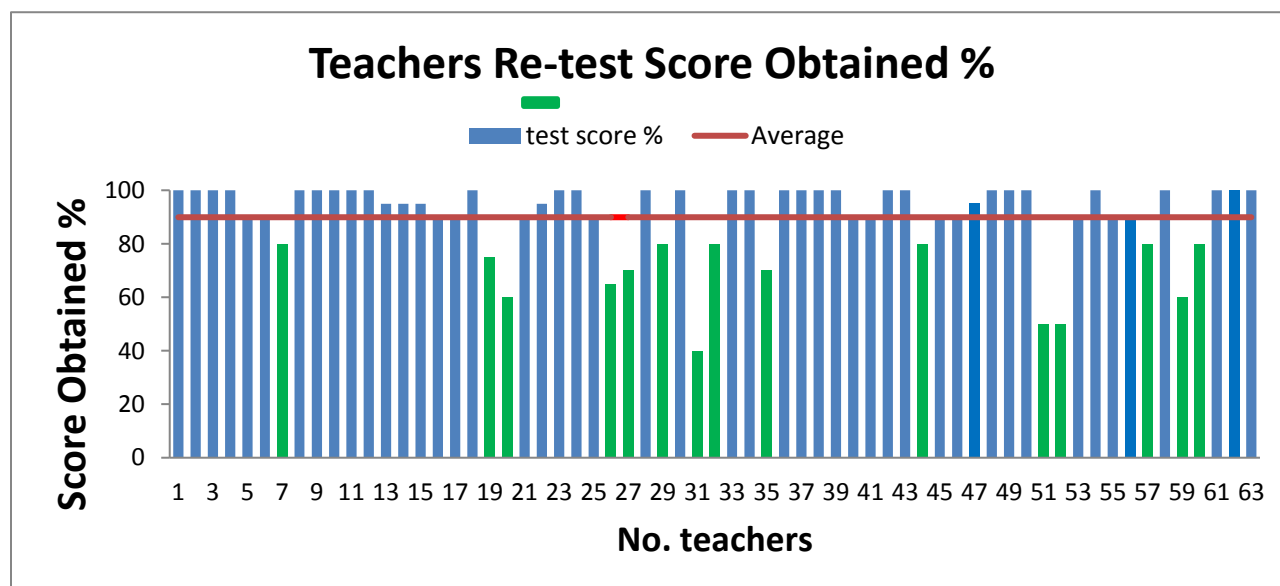


Figure 9: Plot of Re-test score obtained vs. Teacher. No

## ❖ Update Baseline Evaluation

The Update of the baseline evaluation to calculate long-term sigma level which is teacher's awareness level after improvements are shown as:

- **Total number of teachers surveyed (o- opportunities) = 63**
- **Average test Score = 89.921**
- **Number of scores on or above the average score (c) = 48**
- **Number of scores below the average score (d-defects) = 15**
- **DPO (d /o) = (33/63) = 0. 238095**
- **DPMO = (d/o)\*1000000 = 238095**
- **Yield% = 76.19%**
- **Sigma Level =2.21**

## ❖ Improvement Implementation (Process Map)

After improvements have been made a new and appropriate process map was created as shown in [Figure 10]. The improvements were made in teacher reaction. The reaction is to call the nurse and try to take proper action before the nurse arrives. If the nurse arrives she will check the glucose level if good the student will enter his class and continue the day, while if the glucose level was not good the nurse will help the student. After that she will decide if the student needs rest she calls his parents to take him. If the student needs a doctor she will call the ambulance.

## E. Control Phase

The control phase allows the project team to maintain the improvements that have been made. In which the improvements will be adequate for several years. Multiple steps were introduced through a response action plan to meet the goal behind the control phase. To be able to maintain the changes and improvements that have been made for more and more years a Response Action Plan was introduced in [ Table 2]. All the solutions used to keep long term sigma level under control.

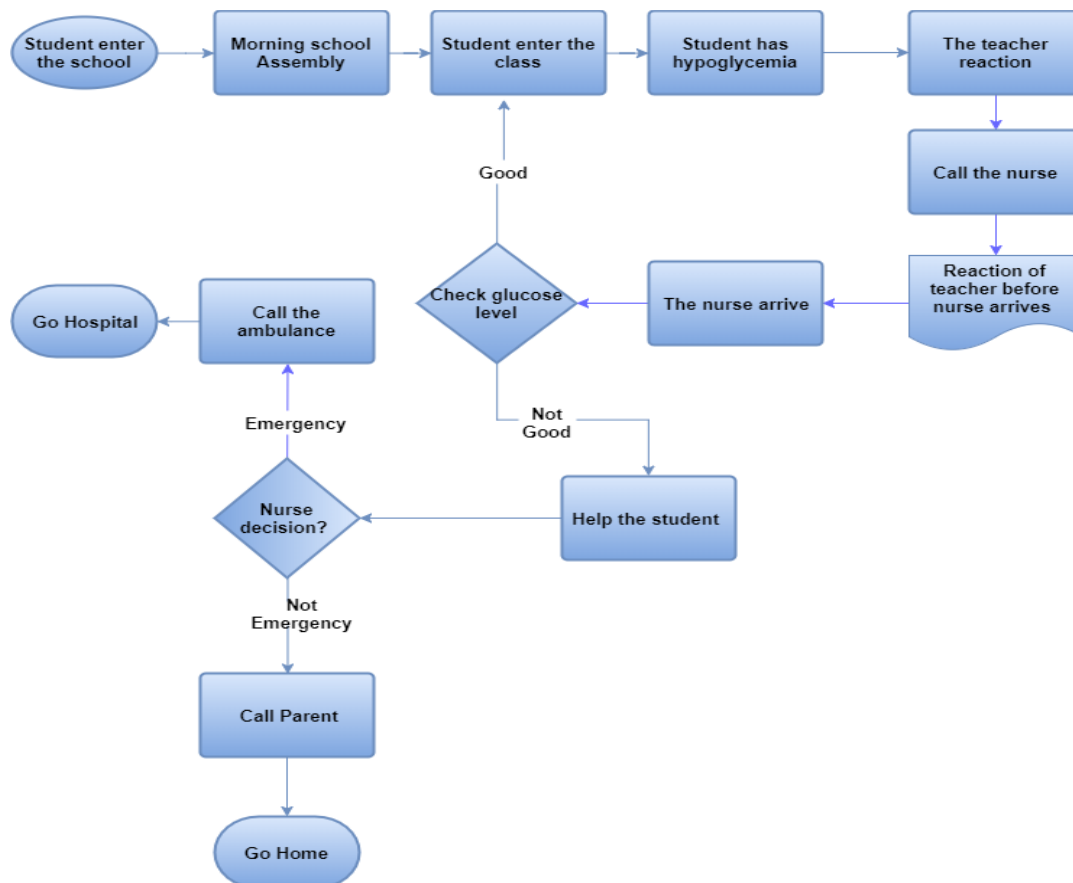


Figure 10: Implementation Process Map

Table 2: Response Action Plan

| Critical variables  | Improvement                              | Error indicator   | Reaction plan  |
|---|--|---|--|
| Constant teachers retest  | Continues distribution of knowledge test | Lack of teachers knowledge  | Distribute knowledge test on a continuous basis to insure that teachers have an efficient amount of knowledge. |
| Teachers and student workshop and assemblies regarding diabetes | Make workshops and assemblies            | Teachers and student inappropriate response towards diabetic conditions | Having a brochures, workshops and assemblies every semester to insure teachers and student remain acknowledge  |
| Availability of healthy meals                                   | Provide healthy meals for students       | Distribute unhealthy food for the students                              | Provide additional healthy meals in school cafeteria such as: blueberry, oranges, cherries, kiwi and tomatoes. |
| Celebrating the diabetes day.                                   | Gain psychological support               | Treating the diabetic child as a student with normal condition          | Celebrating the diabetes day to enhance the diabetic child self- esteem and confidence                         |

## 6. Results

The achievements made were discussed with the stakeholders to be able to implement the improvements in away the school and the hospital will approve it. The project team was aiming to achieve 30% increase of awareness level but instead 32.2% of teacher's awareness level increased due to the improvements and effort the project team introduced throughout the project. Table 3, shows the summary of the results of the project.

Table 3:Summary of Achievements

| Achievements      | Before | After  |
|-------------------|--------|--------|
| Performance Level | 57.7%  | 89.9%  |
| DPMO              | 476190 | 238095 |
| Sigma Level       | 1.55   | 2.21   |

## 7. Conclusion

Six Sigma with DMAIC was successfully implemented in the study to increase teacher's awareness regarding diabetic children in primary schools. All the solutions implemented are resulted in increasing the awareness level of teacher from 57% to 89%. Where sigma level is increased from 1.55 to reached 2.21, therefore the DPMO changed from 476190 to 238095. The same effort can be applied through all the primary schools in Kuwait to achieve higher and improved sigma levels.

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