

# Leveraging Six Sigma Tools and Methodology to Improve Student English Language Performance at Elementary School

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## Abstract

**Purpose:** The purpose of this paper is to discuss how the Six Sigma (SS) methodology can be used to improve the performance of students in English as a second language and enhance the teaching process by utilizing quality tools in an educational environment. **Design/Methodology/Approach:** The paper uses the different quality improvement tools within the Define, Measure, Analyze, Improve and Control (DMAIC) phases to improve student performance in an English language class at a private school. **Findings:** Quality tools, such as cause and effect diagrams and quality function deployment, have been successfully applied within the Six Sigma DMAIC framework in the educational sector to improve the performance of students and enhance the teaching process. **Practical Implications:** This paper helps school administrations to analyze student performance and implement improvement actions to improve their performance. **Originality/Value:** The principal objective of this paper is to demonstrate how quality improvement tools can be introduced and successfully applied in an elementary school to improve student performance and communication between the school administration, teachers and parents.

## Keywords

Six Sigma, DMAIC, Educational Environment, Quality Improvement Tools, Teaching Process

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## 1. Introduction

Six Sigma is a business improvement strategy that attempts to improve the effectiveness and efficiency of all operations (or processes) that deal with customer needs and expectations [1].

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Since its inception at Motorola in the mid-1980s [2], this powerful business management strategy has been exploited by many world class organizations such as General Electric, Honeywell, Bombardier, ABB, Sony, to name but a few in a long list [3].

Six Sigma improvement initiatives are usually deployed through the Define, Measure, Analyze, Improve and Control (DMAIC) phases [4]. DMAIC is widely used when a product or process is already in existence but its performance is inadequate [5]. The DMAIC phases lay out a clear strategy for the deployment of SS projects [6].

Six Sigma as it is today has evolved from mere measurement of quality to an overall business improvement strategy for a large number of companies around the world. Six Sigma applications in the service sector are widespread and have been embraced by many healthcare institutions [7]-[9], financial institutions [10] [11], the construction industry [12] [13], hospitality and tourism [14] and governmental organizations [15].

## 2. Literature Review

A pilot study using the Six Sigma methodology was conducted by Hargrove and Burge [16] to assess, evaluate and monitor variation in student performance in the curriculum. The focus of the study was on the performance of minority and under-represented students in science and engineering programs. Specifically, the authors wanted to “retain the students currently enrolled, increase graduation rates, and the result is a more efficient process of producing well-qualified engineers to meet the technological needs of our nation.” They identified three critical success factors: the need for increased financial aid, faculty development and the improvement of instructional quality.

Burtner [17] described a proposal to adapt Six Sigma process improvement methods in engineering education at Mercer University. The implementation of Six Sigma involved a systems approach to problem solving and emphasized the three C’s: common metrics, constant communication and culture change. Four potential Six Sigma projects were identified at the Mercer University School of Engineering, and these addressed issues ranging from retention and student success in mathematics classes, a reduction in the amount of time taken by students to graduate from an engineering program and the success of women as engineering students.

Hoerl and Bryce [18] discussed the current status of Six Sigma in universities as well as its potential influence in an academic environment. As a proven successful strategy in many business organizations, it is largely under-applied in university settings. Applying Six Sigma in a university is difficult due to the intangible nature of the educational product, the diversity of departmental and individual goals and viewpoints, and the administrative focus on seeking funding for the university’s programs.

Holmes *et al.* [19] listed several differences in implementing Six Sigma projects in a university environment rather than in manufacturing. The nature of the product, customer definition, quality measurement and employee reward systems differ significantly. A university is in full operation for only nine months of the academic year. A company operates for 12 months annually and it can also be more outcome-oriented. On the other hand, shared governance in academia can lead to a much slower decision making process. Students at a university are also partially responsible for their own learning-this single factor complicates the problem significantly. The challenges include the difficulty in defining the customer for a university, the nature of the product, and the difficulty of measuring quality and reward systems for employees.

A study by Jenicke *et al.* [20] focused on identifying critical factors for implementing Six Sigma in academic institutions such as universities. They proposed a comprehensive framework that would guide academic institutions planning to implement Six Sigma.

Kaushik and Khanduja [21] reviewed the implications of applying Six Sigma methodology at a technical institute to increase the passing rate of students.

Prasad *et al.* [22] presented a case study that was undertaken in a reputed engineering educational institution in Southern India.

Ramasubramanian [23] discussed the role of Six Sigma for transforming higher education and outlined how Six Sigma may be used in the operation of all of the existing work processes in an institution in the best possible manner.

Dhariwal and Bhagchandani [24] presented a case in which they applied the Six Sigma DMAIC approach in an undergraduate technical institute in Dubai, UAE, to improve student performance in a course named “Introduction to Operations Research” (OR).

This paper presents the results of a case study in a private elementary school that has applied the Six Sigma

DMAIC methodology to improve student performance in English. The difficulty of measuring some aspects relating to human knowledge made the application of Six Sigma in education research rather challenging; however, the facts suggest that different fields in the educational institutions can be significantly improved by applying the Six Sigma methodology as shown in **Figure 1** [25].

### 3. Background

We considered the English Language Department (ELD) at a private school. Specifically, the primary department consists of the first three grades with 27 classrooms and a total enrollment of 697 students. The ELD consists of 14 teachers in the primary department, who teach the McGraw Hill Reading curriculum (**Table 1**).

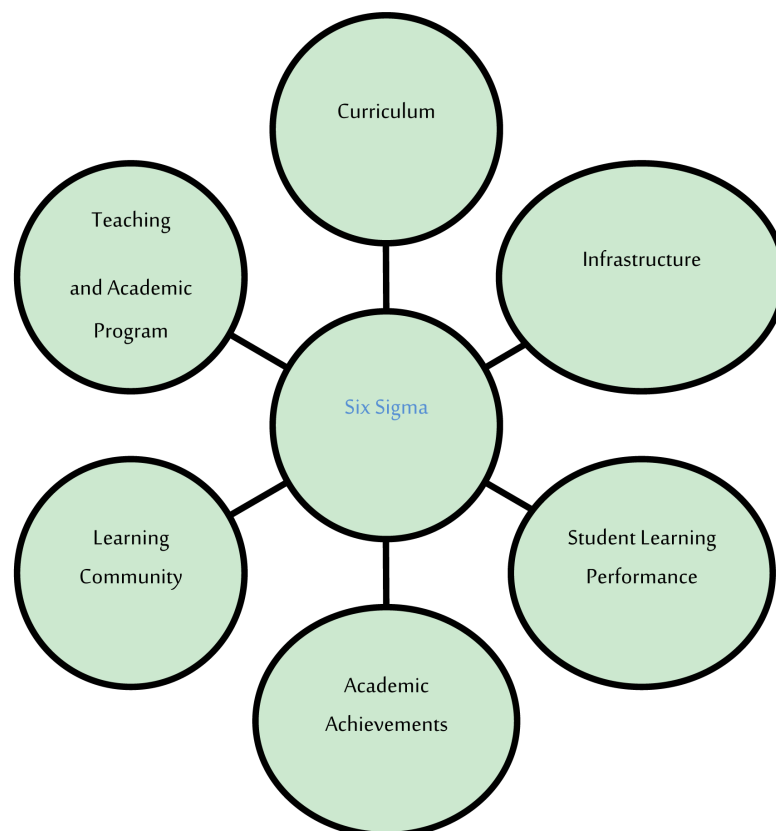
The school has started an English Language Intensive Program (ELIP), and students who perform poorly are encouraged to enroll in the program. The ELIP consists of an additional two periods a week to improve the students' basic English language skills.

### 4. Methodology

#### 4.1. Define

The Define phase of the DMAIC process is often skipped or short-changed, but it is vital to the overall success of any Six Sigma project. The objective of this first stage is to determine what needs to be improved. A clear project definition is vital to the success of the SS project implementation. The deliverables for this phase are: 1) the team formation, 2) the preliminary process map, 3) the Voice of the Customer (VOC) and 4) the project charter.

The improvement team was composed of Six Sigma black belt and Six Sigma green belt candidates, the process owner (the head of the ELD) and the project champion (an industrial engineer in charge of the quality department in the school).



**Figure 1.** Common fields in education can be improved by applying Six Sigma [25].

**Table 1.** Student enrollment distribution.

Grade Classification	Number of Students in a Class (Range)	Number of Students (Male & Female )	Number of Classes	Number of Teachers	Number of English Periods Weekly*
First	18 - 25	238	10	5	9
Second	26 - 29	219	9	3	9
Third	25 - 29	240	8	3	7

\*Each period is 45 minutes.

An SIPOC diagram was created to solidify each member's understanding of the teaching process. The SIPOC diagram is shown in **Figure 2** and is used to identify the relevant elements of the process.

The SIPOC diagram helps to define the process boundaries and identify the stakeholders. The teaching process starts with preparation and ends with evaluation.

A brainstorming session with all of the team members was conducted to gather relevant information. The many ideas that were generated were sorted using an affinity diagram.

The team decided to consider students with grades below a threshold as requiring special attention and encourage these students to attend the ELIP.

The percentage of students requiring special attention was used as a key performance indicator. The percentage of students requiring special attention was based on first grade students with grades below 79% and second and third grade students below 75%. The the percentage of students requiring special attention at the beginning of the project is 13% which as considered high by the school administration.

The project objective was to improve student performance by lowering the percentage of students requiring special attention to an upper specification limit (USL) of 10%.

## 4.2. Measure

The second step in the SS–DMAIC process is to measure the data and organize it in a way that is easily accessible for interpretation and analysis. This is a very important process that helps to better understand the problem in order to reach a solution. An important step in the measure phase is data collection.

### Data Collection

The team decided that the best approach for collecting the data was via observations, interviews, surveys and school visits, as illustrated in **Figure 3**.

### The Curriculum

A focus group of six qualified experts in the field of English instruction and curriculum studies directed by the head of the ELD conducted a study to evaluate the curriculum and the learning outcomes. The focus group also compared the current curriculum (McGraw Hill Reading) to others and concluded that the current curriculum was the most appropriate for use in the school.

### Classroom Environment

The team attended English classes for the first, second and third grades. This provided an opportunity to closely observe the classroom environment, especially teacher/student interactions and to closely note how teachers interacted with students.

### Surveys

The team prepared two surveys, one for parents and one for teachers. The surveys consisted of two parts. The first was a statement that was intended to measure the degree of acceptance. The second part was in an open-ended format to allow respondents to express their remarks and explain and expand on ideas concerning the questions. The surveys were prepared and tested to ensure question clarity. The surveys were filled out either in person or over the phone during a two month period. **Table 2** presents information about the questionnaires.

### Parents' Surveys

**Figure 4** presents the results of the first part of the parents' survey that compares the answers for students who attended the ELIP (referred to as ELIP in the figure) and those who did not attend, referred to as regular (shown as Reg. in the figure). We combined the answers for parents of students in different grades because there were no statistical differences between their answers.

**Figure 4** shows that interest in learning English affects student performance and that 72% of parents of stu-

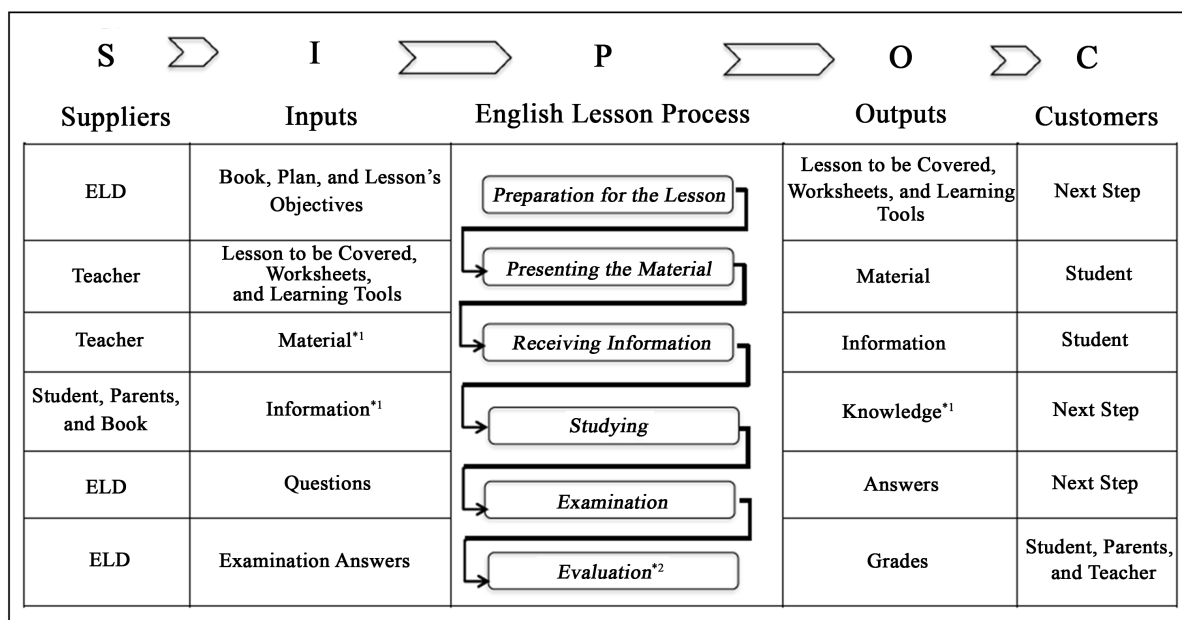


Figure 2. SIPOC diagram for English periods.

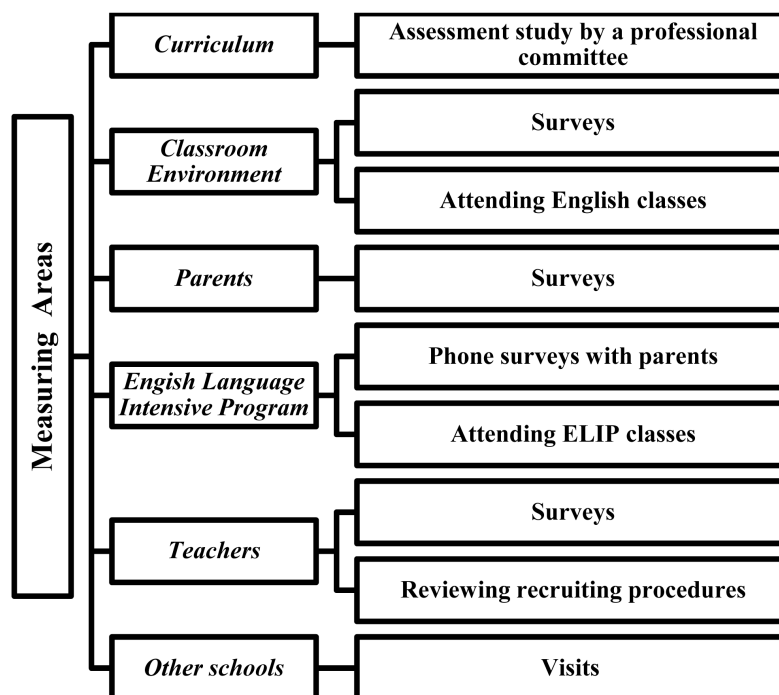
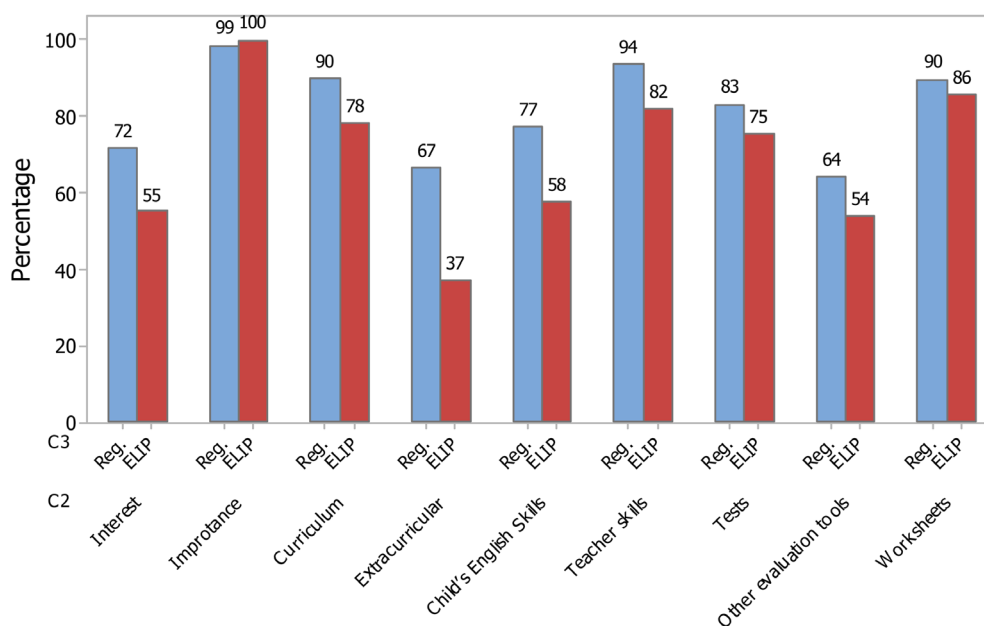


Figure 3. Data collection methods.

Table 2. Questionnaires distribution.

	Method	Number
Parents	Personal	172
ELIP	Phone	78
Teachers	Personal	12



**Figure 4.** Parents' survey results.

dents who did not attend the ELIP believed that their children were interested in learning English, while only 55% of parents of students who did attend the ELIP believed their children were interested in learning English.

Parents of both groups believed that learning English is important.

Sixty seven percent of parents of regular students were satisfied with the extracurricular activities, while only 37% of parents of ELIP students were satisfied.

It is apparent that 58% of parents of ELIP students believed that their children had good English language skills, indicating a problem with their assessment and a lack of communication between the school and the parents.

Regarding ELIP, 40% of the weak students did not attend the intensive program because:

- A) Their parents believed that the intensive program was ineffective.
- B) They had a private tutor.
- C) Their primary English teacher believed that it was unnecessary.
- D) The program was offered at an unsuitable time.
- E) The parents were not aware of the program.

The survey also indicated that only 25% of parents of ELIP students were satisfied with the results of the program.

The answers to the second part of the survey were compiled and summarized in a Pareto chart, as shown in **Figure 5**.

The parents felt that the students were weak in the area of verbal communication; they also indicated a need for workshops to learn how to follow up with their children's learning. The parents expressed a need for extracurricular activities such as learning through playing and reading stories.

### Teachers' Survey

**Figure 6** presents the results of the first part of the teachers' survey.

Regarding **Figure 6**, the following points can be made.

When asked about the integration between the English lessons and the math and science lessons, about 62% of the teachers indicated some degree of integration, and 77% indicated that math and science classes impacted the students' ability to learn English.

It is noteworthy that when the teachers were asked about how the school administration responded to their needs, 92% of the respondents were satisfied; however, only 17% were satisfied with the school's incentive system and only 46% were satisfied with the overall environment.

As an alarming note, only 46% of the teachers found the ELIP to be effective.

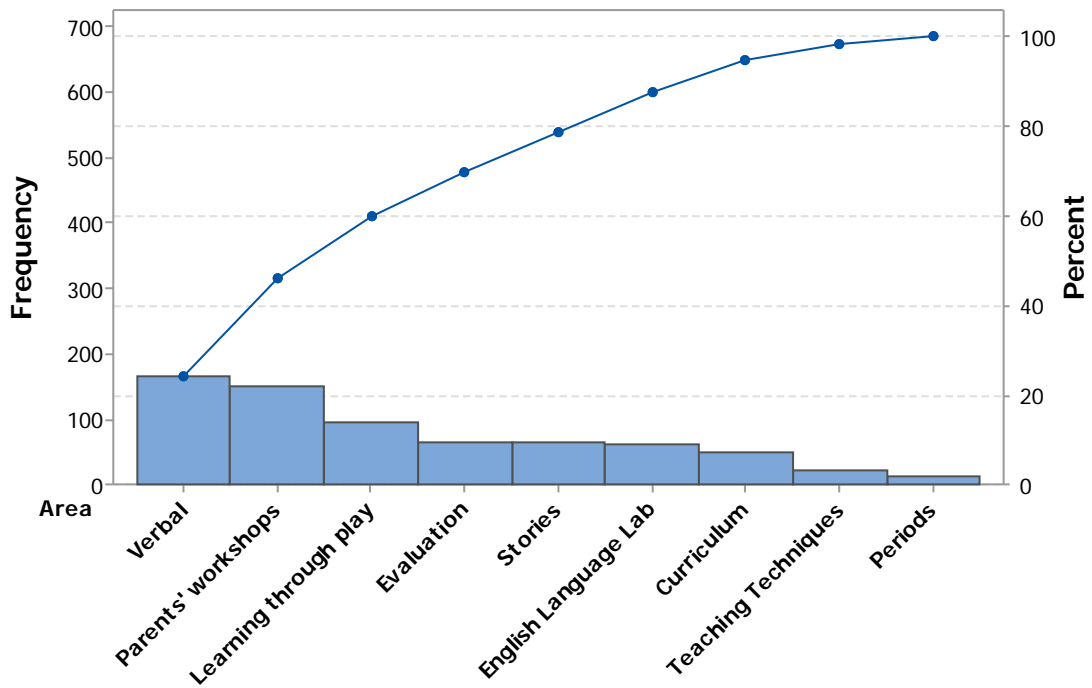


Figure 5. Pareto chart for parent suggestions.

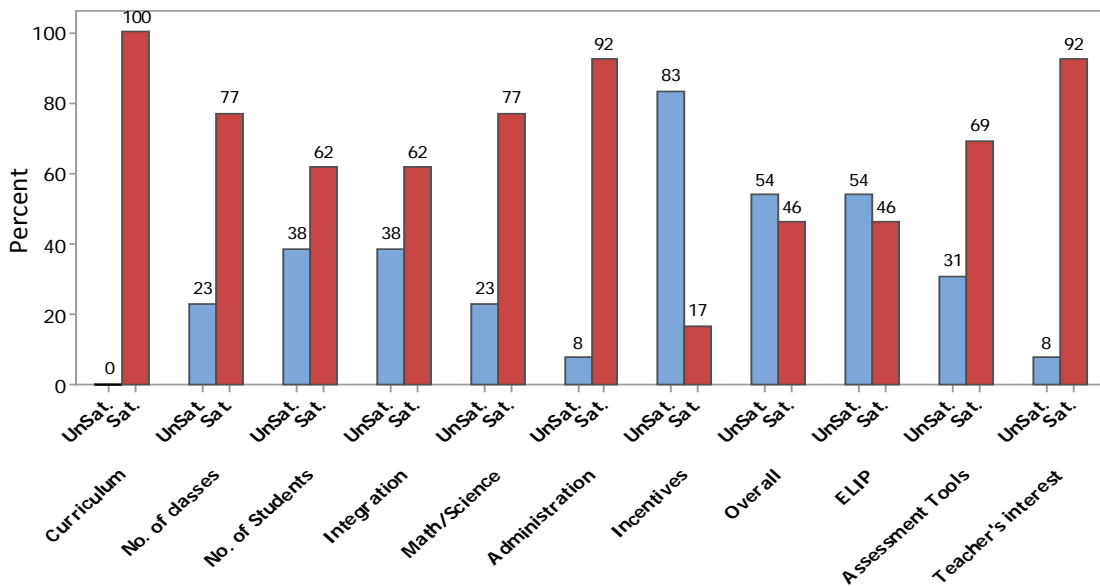


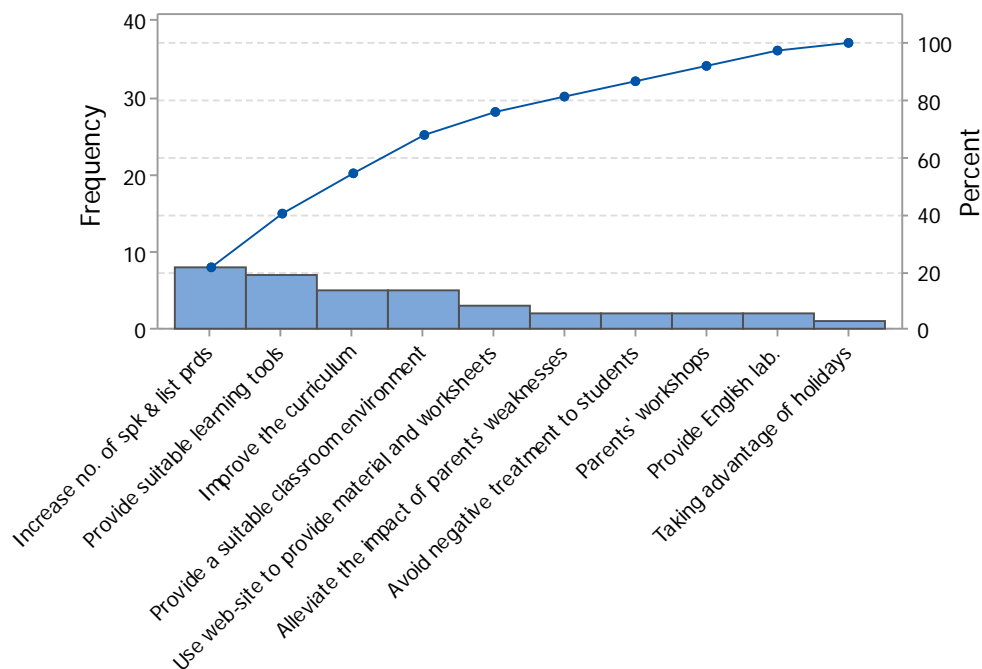
Figure 6. Teachers' survey results.

Although the 92% satisfaction rate was high, it was expected that the teachers' interest in teaching should be 100%.

The answers to the second part of the survey were compiled and summarized in a Pareto chart, as shown in Figure 7.

### Other Schools

The improvement team visited two schools that are known for their strong English language programs. Information gathered during the visits will be used in a bench marking process as part of constructing the quality function deployment performed in the Improve phase.



**Figure 7.** Pareto chart for teacher remarks and suggestions.

### 4.3. Analyze

Based on the information gathered in the measure phase, a fishbone diagram was created and is shown in **Figure 8**. A brief discussion and elaboration of the information presented in the figure follows.

**Communication** between all stakeholders appeared to be a major concern and caused disconnect between stakeholders and repeated work effort.

**Teacher training:** teachers were provided with improper and inadequate training, especially when compared to other schools as indicated in the quality function deployment (QFD) shown in **Figure 9**.

**Teaching tools and methods:** the teachers were only provided with textbooks as learning tools, lecturing was the prevalent teaching style and only traditional educational media such as a blackboard was used. Hence, students became easily bored in class.

Worksheets distributed to the students were unclear and thus parents and students did not know how to use them.

### 4.4. Improve

The information gathered in the Analyze phase was brought to several brainstorming sessions and meetings with the teachers (VOE). In these meetings, the improvement team constructed a QFD where the VOC and VOE “the what” are translated into technical requirements “the how”. **Figure 9** shows the first level QFD.

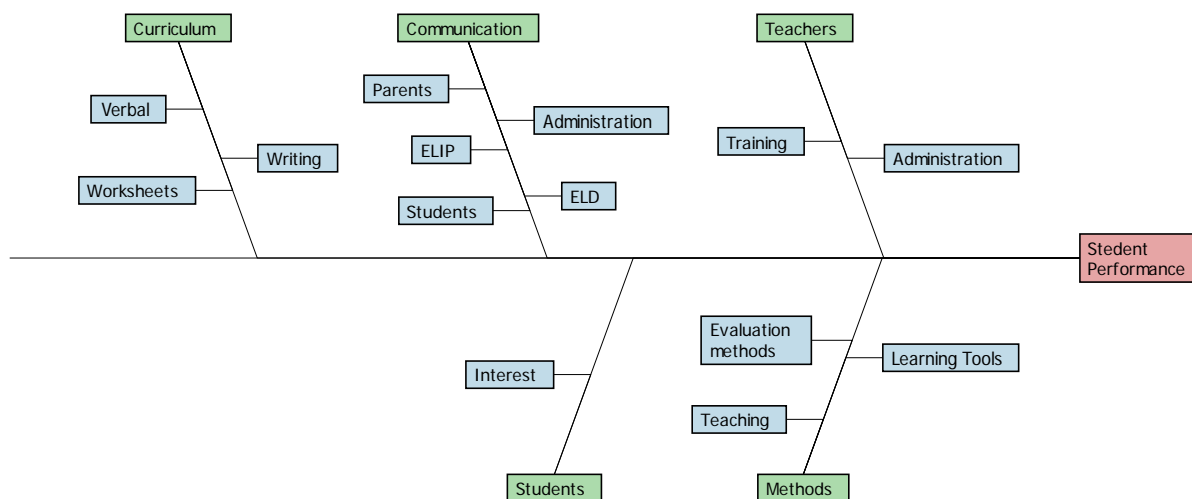
In many cases, further elaboration on the technical requirements led to the introduction of a second level QFD as shown in **Figure 10**.

The team also prepared a Kano model to classify the parents’ and teachers’ requirements into three well-known categories of customer satisfaction, the basic level, the performance level and the excitement level, as shown in **Figure 11**.

In a meeting, the team presented its findings and a proposed improvement action plan to the school administration for discussion and approval.

Feedback from the school administration required modification of some of the items in the action plan such as an increase in the number of teaching periods per week. Due to limited numbers of teaching hours and constraints enforced by the Ministry of Education, the school administration was not able to implement an increase to 10 periods per week. However, they integrated several subjects such as art, computer and physical education (PE) with the English language class.





**Figure 8.** Fishbone diagram for the information gathered in the measure phase.

The school administration also decided to study the feasibility of limiting the number of students in each class to a maximum of 22.

The school administration also decided on setting new policies and procedures for hiring new teachers. The hiring process was reviewed and any sign of lack of interest in teaching was noted and evaluated. Candidates who did not show keen interest in teaching would be disqualified. New teachers are required to attend training programs before starting at the school, including workshops focused on creative teaching methods.

The improvement action plan had four facets.

First, ELD teachers participated in regularly held meeting to share experiences and discuss concerns. Each teacher had to present an innovative idea at least once during a semester.

Second, regarding communication with the parents, the ELD organized several meetings to provide continuous feedback and updates on student performance and workshops for the parents to provide supplementary information and material to reinforce student learning. Text messages were sent to parents to remind them about the workshops and meetings.

Third, concerning the curriculum, [Table 3](#) shows the parts of the improvement action plan.

Fourth, several actions were taken to improve the ELIP:

- 1) A special training program for ELIP teachers was prepared.
- 2) A progress report for each ELIP student was prepared including information about the students' English language skills and opportunities for improvement. The report was prepared and reviewed by the primary English teacher and the ELIP teacher.
- 3) A regular meeting was held between the primary teachers and the ELIP teachers to review the progress reports of the students.
- 4) Special worksheets dedicated to the intensive program students were prepared.

After implementing the improvement actions, the students' progress was monitored by the ELD and their grades were recorded for four years. A capability study was conducted and the results are shown in [Figure 12](#). The percentage of students who required special attention dropped below the USL of 10%, although in the last year, it went up to 14%. This was expected since the evaluation method was changed.

#### 4.5. Control

The control phase is the last of the DMAIC phases. This phase identifies the controls that must be in place to ensure that the improvements and benefits of the new processes can be consistently maintained and controlled. The control phase must be carefully performed and reviewed in order to keep the evaluation consistent, avoid mistakes and prevent quality deterioration. In this phase, the improvement project leadership is transferred from the project leader to the process owner (the ELD head). [Table 4](#) presents some of the control actions that were required to sustain the gains and avoid decay.

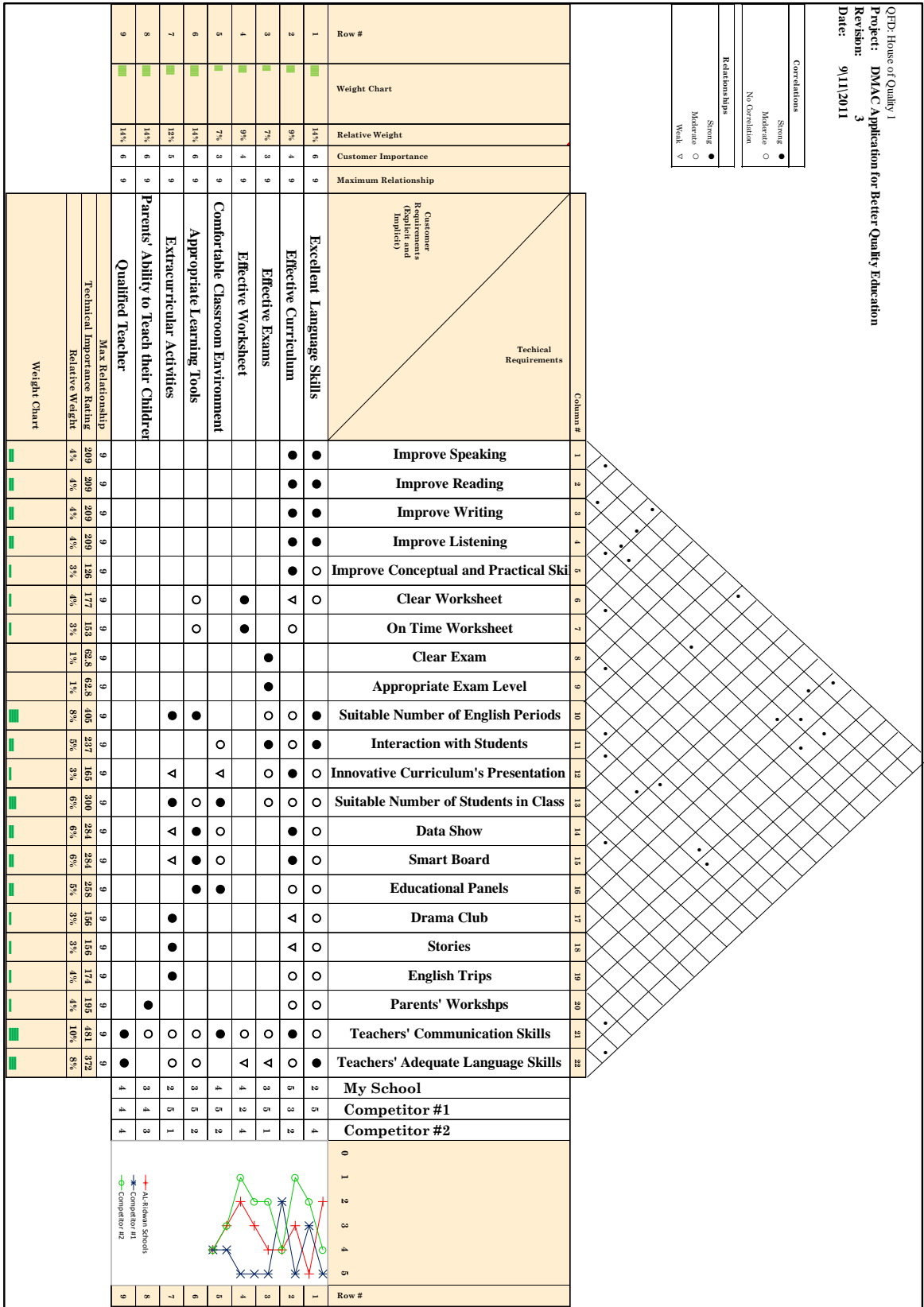


Figure 9. First level quality function deployment.

QFD House of Quality 2  
 Project: DMAC Application for Better Quality Education  
 Revision: 3  
 Date: 16/11/2011

Correlations	Strong ●
	Medium ○
	No Correlation
Relationships	Strong ●
	Medium ○
	Weak ∇

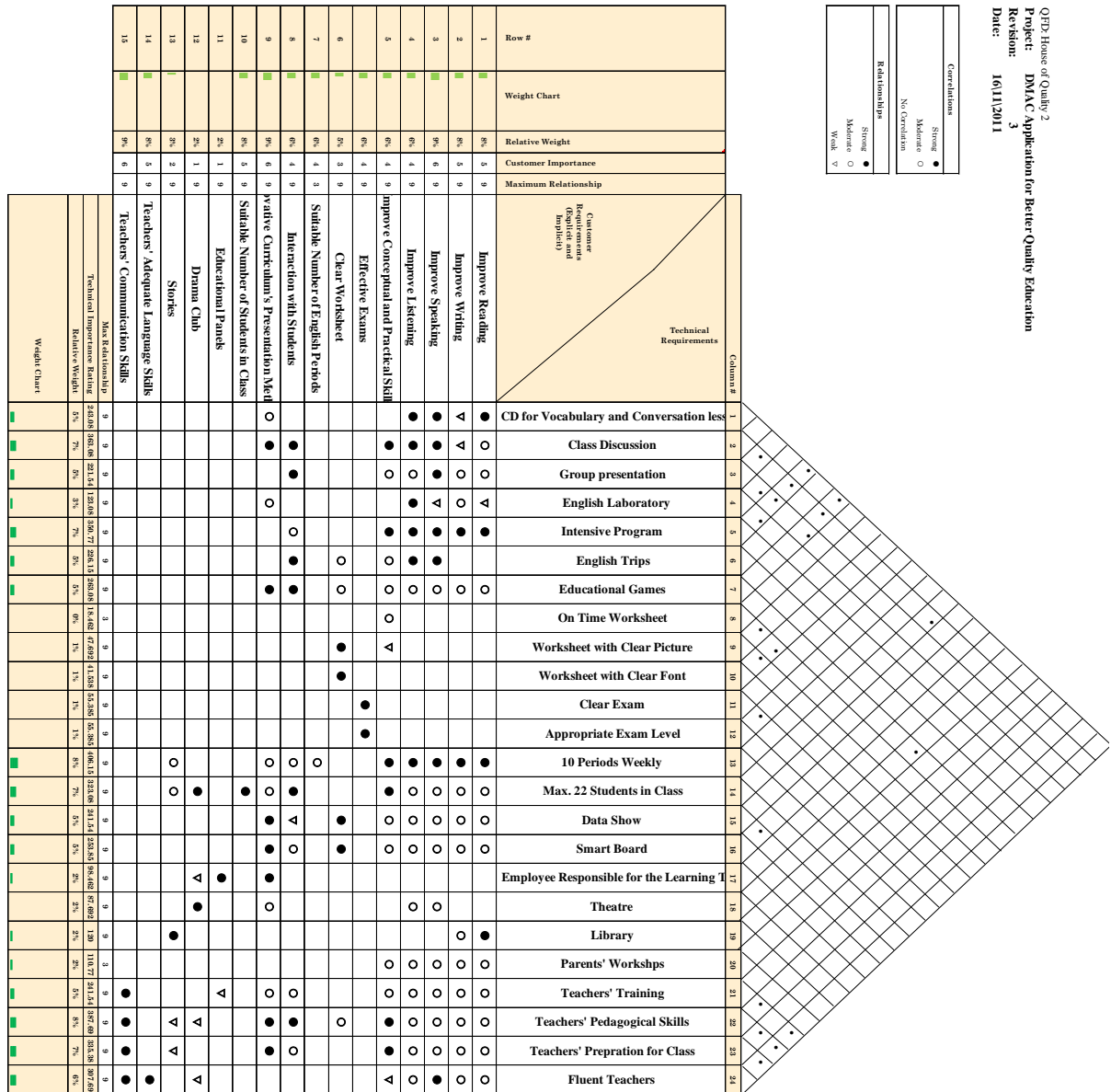


Figure 10. Second level quality function deployment.

Table 3. Improvement action plan: curriculum.

Key process area	Recommendations proposed
Learning tools	<ol style="list-style-type: none"> <li>1. Provide CD for phonics vocabulary</li> <li>2. Recruit an employee responsible for the learning tools</li> <li>3. Provide smart board and data shows</li> </ol>
Stories	Establish reading corner
Extracurricular activities	<ol style="list-style-type: none"> <li>1. Establish drama club</li> <li>2. Add an English section to the school website for learning videos, worksheets and weekly reports</li> <li>3. Entertainment trips supporting English language</li> </ol>
Integration of educational subjects	Relate art, computer and PE periods with English

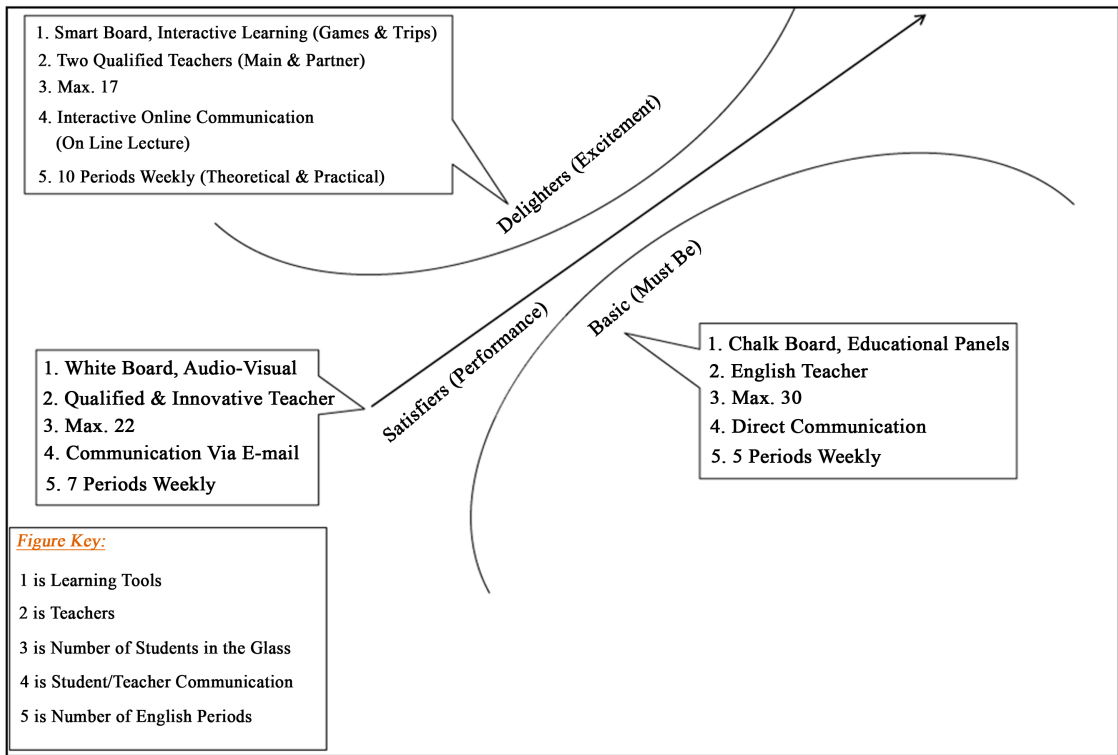


Figure 11. Kano model for English period.

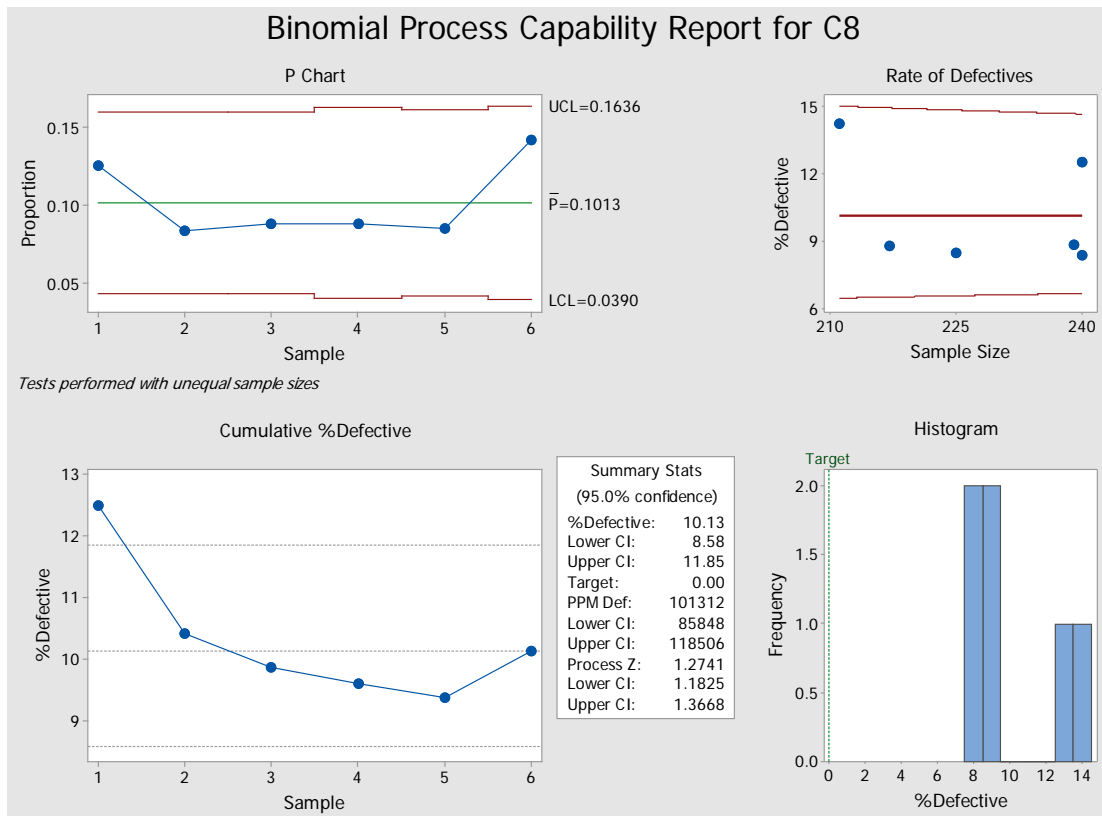


Figure 12. Student grade process capability report.

**Table 4.** Control actions.

Key factor	Control action	Responsibility
New teachers	ELD head attends three periods monthly to evaluate the performance of new teachers using a special evaluation form	ELD head
Old teachers	ELD head attends one period monthly to evaluate the teacher	
Worksheets clarity	Worksheets are checked and copied from original sheet	ELD secretary
Experience exchange program	The program was put in place to circulate pedagogical experiences for which each teacher is required to attend two periods for other teachers	All teachers
Integration of PE, art and computer with English language	Integration of educational subject with English: Head of ELD prepared a weekly plan for PE, art and computer teachers	ELD head
ELIP student performance	A progress report was prepared for teachers to write down all points of weaknesses and the applied procedure, to ensure that the primary English teacher is involved along with the intensive program teacher in helping ELIP students	English teacher and ELIP teacher

### Lessons learned

The control phase also includes documentation and sharing of the lessons learned. Lessons learned can make all the difference regarding the success of future projects. By listening to the project team, the champion was able to gather the feedback and identify the project obstacles and success factors. For new initiatives to succeed, it is usually best to take a top-down approach. One essential reason behind the success of this project is the school administration fostering and supporting the creation of a continuous improvement culture in the school.

On the other hand, the biggest obstacle was transferring the school from a traditional functional mindset to thinking about the process. The traditional functional paradigm impeded customer-and employee-focused performance improvement projects. This mindset made it difficult to respond to their needs. Process thinking is critical to reduce conflict and encourage greater connectedness within the school between the administration, ELD primary teachers and ELIP teachers and the parents, leading to a more positive environment manifested by better organizational connectedness and less internal conflict.

## 5. Conclusions

The literature provides many examples applying DMAIC Six Sigma methodology in improvement projects in the manufacturing and service sectors. The purpose of this paper is to demonstrate that the methodology and tools of Six Sigma can be successfully applied to improve student performance in English as a second language at an elementary school.

This project provided a good platform for introducing the Six Sigma DMAIC methodology and tools to improve performance and solve process problems in different departments in the school, in spite of the immense challenges faced when implementing the Six Sigma method successfully in an educational setting, one of which was that students were partially responsible for their own learning. The project also offered an opportunity to show the importance of cross-functional communication for solving problems. Logical analysis and qualitative tools were employed throughout the DMAIC phases to define and identify root causes that affected the educational process. The forms and documents resulting from this project provided a good knowledge base for the various departments to manage their teaching processes.

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