Application of Lean Six Sigma to Improve Values in Educational Institutions

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Educational institutions are under intense pressure from stakeholders to improve quality and effectiveness. Although the Lean Six Sigma (LSS) methodology has gained increasing attention in various educational processes for reducing waste and defects, its capability has not yet been well studied in value education. In this study, a framework based on the DMAIC Six Sigma approach, and Lean concepts is proposed and applied in a school. The results of this study highlight that LSS can be used effectively to suggest guidelines for increasing educational effectiveness and stakeholder satisfaction over a relatively short period.

Keywords: Lean Six Sigma, Value, Control Chart, Educational Effectiveness, DMAIC Approach

1. Introduction

Educational institutions are under intense pressure from stakeholders to improve quality and reduce waste and defects. Six Sigma has been very effective in reducing variation and defects within processes, and Lean has proved to be very powerful in reducing waste or non-value-added steps between processes (Antony, 2014; Montgomery, 2017).

Six Sigma is a management philosophy with a set of statistical and quality improvement tools that aim to improve quality, meet customer expectations, and reduce defects to as few as 3 or 4 per million opportunities. Six Sigma integrates business-level performance, process measures, and project metrics into a systematic process, enabling leaders to manage the organization quantitatively and transform business strategy into calculated tasks.

The foundation of the Six Sigma process is a problem-solving approach for eliminating the root causes of problems. It suggests two problem-solving approaches, namely DMAIC and DMADV, which are acronyms for Define-Measure-Analyze-Improve-Control and Define-Measure-Analyze-Design-Verify, respectively. Each one of these approaches incorporates several lean and quality improvement tools and techniques (Sunder et al., 2015).

Many Fortune 500 firms, including some major service firms, claim to have serious Six Sigma programs. Sunder et al. (2017) reviewed the literature on Six Sigma and Lean for services and constructed a Morphological Analysis framework.

Examining Six Sigma in the context of education was undertaken by Man in 2002. He developed and used the DMAIC approach to establish "lifelong learning" educational standards for adults (Man, 2002). Antony et al. (2008) addressed some limitations of Six Sigma in educational environments that should be managed before deployment. One of the most significant constraints is the lack of standards, which can

cause variability in education. Applying the Six Sigma approach requires consideration of all related activities such as curriculum design, learning goals of courses, classroom teaching, lab exercises, and student learning.

The Six Sigma methodology does not necessarily take much time and can usually be implemented in six months. Florida State University's School of Statistics engaged students in seven different projects during one semester. In the first project, students listed two professional goals. The next five projects followed the DMAIC process, and the final project required a report on the overall process. By applying DMAIC, students achieved their goals and familiarized themselves with the system.

Mazumder (2014) applied Six Sigma with Statistical Process Control (SPC) in another study to improve quality in higher education, addressing main problems and proposing approaches for process improvement. SPC is a powerful set of monitoring and process control tools essential for improving process capability and stability by reducing variability (Montgomery, 2009). SPC consists of seven quality improvement tools, with the control chart being the most important. A control chart is a graphical technique to analyze variations in a process. Control charts have two phases. In Phase I, process data are collected and analyzed retrospectively, and control charts are plotted. The focus is on distinguishing between in-control conditions and assignable causes to estimate in-control parameters for further monitoring in Phase II. In Phase II, process performance is monitored by comparing the statistics of consecutive samples, and corrective action is undertaken if there is assignable cause variability. Control charts differentiate between common cause variability and assignable cause variability using rules such as Western Electric rules and help eliminate the latter (Montgomery, 2009).

LeMahieu et al. (2017) presented the theoretical foundations, core principles, and a case study demonstrating the application of Six Sigma in a school-community partnership in Milwaukee, Wisconsin. The core principles included decreasing variability in organizational work processes, eliminating waste, identifying, and reducing defects, lowering the cost of work processes, and improving beneficiary/client satisfaction levels.

Integrating Six Sigma with Lean provides a useful toolkit for improving service quality and acts as a management strategy for Quality Excellence (Sunder and Antony, 2018). Lean thinking originated on the shop floors of Toyota Motor Corporation (Shingo, 1988). This approach aims to simplify processes and eliminate waste to increase productivity and create continuous value in organizations by accomplishing tasks with fewer resources.

Following its initial application in manufacturing, Lean has spread rapidly into the service sector and now into education. Proponents of Lean implementation in educational institutions have identified its positive impact on the sector (Balzer et al., 2015; Emiliani, 2015). As a result of several successful applications, Lean has become an essential option for managers and is increasingly utilized (Thomas et al., 2017).

The application of Lean programs in education has been a topic of academic debate and development. However, practically defining some Lean concepts in educational institutions (such as inventory and pull/push systems) can be challenging. The Lean approach can improve the education process by focusing on waste and value stream concepts if educational and psychological foundations are considered. Although Lean theory is relatively new in education, some teachers have used this approach to improve student learning and eliminate waste in teaching processes for years (Ziskovsky, 2007). Waste such as over-reviewing prerequisites, unnecessary introductions, reworking obsolete topics, and waiting for students can be removed during a Lean process (Nadeau, 2017). Markham (2013) identifies waste in

universities in four categories: human, process, information, and wealth. These wastes include non-standardization, poor planning, error correction, and excess equipment and facilities.

Quality is usually defined according to customer expectations and needs. Therefore, identifying customers is crucial in quality improvement tools such as Six Sigma and Lean. Researchers define customers as students (Hess and Benjamin, 2015). Although this definition may simplify improvement tools, support staff may be exposed to increased occupational health and safety risks (Leclerc and Bourassa, 2013). Other researchers consider students, parents, teachers, professors, employees, employers, and society as customers. In this study, we consider students, parents, teachers, management, and support staff as customers.

Despite Lean Six Sigma (LSS) receiving increasing attention in various educational processes, its capability has not been well studied in the process of value education. This is important because the goal of education in institutions, especially schools, is not merely acquiring scientific knowledge and life skills but also the value education of students to prepare them to live in the community (Ornstein & Levine, 2008). This research starts with an overview of the concepts and literature. In Section 3, a framework is proposed based on the DMAIC Six Sigma approach and Lean concepts in the context of the school. Section 4 discusses the performance of LSS, and the general conclusion is presented in Section 5.

2. Literature Review

2.1 The Educational Process of Values

The argument for the moral purpose of schooling is common in education research literature. For this reason, many commentators regard teaching as a moral enterprise. Values, as a social phenomenon, have played a significant role in human life since the formation of early communities. They are beliefs and frameworks that define appropriate behavior for individuals and direct them. Values also serve as guiding principles in all situations, including working environments.

Values education can be defined as the aspect of educational practice in which moral or political values, as well as norms, dispositions, and skills grounded in those values, are learned by students (Thornberg, 2008). Although the concepts of values education and moral education are often used interchangeably, in this study, we use the term values education which includes concepts such as moral education, character education, and civic education.

The education of values can be divided into two distinct categories: explicit and implicit education. Explicit education of values involves the formal school curriculum concerning types of values, while implicit education of values involves an informal and implicit curriculum, where values are presented indirectly in school and classroom settings (Thornberg, 2008). Values education can take various forms, such as community meetings for democratic decision-making, discipline committees for addressing misbehavior, and moral dilemma discussions in the classroom to enhance moral reasoning (Oser et al., 2008).

The educational process of values typically begins with determining educational needs to identify the most important values to enhance. The next step involves designing and implementing both explicit and implicit educational programs. Teachers usually provide education because they spend the most time with students, but it is also supported by a favorable school climate and other employees. The final stage is

evaluating the training outcomes to determine the effectiveness of the previous stages (Daneshmandi et al., 2020).

Koh (2012, p.86) believes that storytelling is particularly useful for developing personal beliefs through narratives and for identifying and clarifying values. Lovat et al. (2011) demonstrated the effects of values education on enhancing students' academic diligence by creating a more positive school ambiance. Cubukcu (2014) categorized value education approaches into four types: The Trait Approach, Values Clarification, The Cognitive Developmental Approach, and Role-Playing. Sporre (2018) described the Swedish system of assessing ethics education in compulsory schools through national tests. The results suggested that ethics education, given (a) the curricular construction of what ability to assess, (b) the complexities of test construction in ethics, and (c) possible consequences of test teaching, strengthens the school's position. When overviewing European ethics education in compulsory schools, Korim and Hanesová (2010) noted that ethics education is organized differently in different countries due to historical, cultural, ideological, political, and economic factors.

2.2 Lean Six Sigma in Education

Lean Six Sigma (LSS) is a combination of two robust continuous improvement methodologies: Lean and Six Sigma. LSS has been successful in many organizations worldwide, improving capability, reducing production costs, maximizing shareholder value by enhancing quality and increasing customer satisfaction (Snee, 2010).

Sunder et al. (2017) indicated that integrating Lean with Six Sigma could bring more synergies to organizational processes, especially in the services sector. Antony et al. (2012) discussed whether LSS could be a useful and systematic approach to tackling operational and strategic issues in higher education institutions (HEIs). They used secondary data from the literature to justify the need for this approach and highlighted the benefits of adopting this business process improvement strategy within HEIs.

Sunder and Antony (2018) suggested a six-stage conceptual framework for deploying LSS in HEIs, acknowledging that education sectors are significantly different from the manufacturing sector, where LSS originated. The framework begins with LSS readiness, aligning the organizational vision for quality excellence through leadership. Next, it involves developing an LSS deployment strategy, educating stakeholders (students), and forming teams. Once these steps are correctly implemented, identifying, and executing LSS projects becomes critical, leading to quality excellence in HEIs.

Haerizadeh and Sunder (2019) demonstrated the applicability and impact of LSS for improving the education system at a reputed university in Iran. They used a case study approach to show how theory is put into practice, explaining the implementation of the LSS DMAIC framework in a higher education institution and highlighting the challenges and lessons learned. Implementing LSS into curriculum design and delivery allowed the team to prioritize critical variables, applying the most appropriate tools and techniques at key points to achieve maximum performance (Thomas et al., 2017).

Despite some successes, there is currently no widespread use or acceptance of LSS in the education sector (Montgomery, 2017). Most studies on using LSS in education focus on theoretical concepts, with little attention to experimental data and practical implementation (Assarlind et al., 2013; Nadeau, 2017; Shruti and Kant, 2017). This neglect may be due to the novelty of these concepts in educational environments, a lack of LSS knowledge and experience among employees, and a lack of metrics and key quality indicators that can mask many problems (Montgomery, 2017). Therefore,

focusing on metrics and practical application of these concepts and establishing a connection between the components of these tools and educational structures is essential.

Performance data have gained importance in summarizing complex phenomena across different locations and over time to identify and compare effective educational practices (Hacking, 1983). This data is used to inform and improve teaching quality, hold individuals and organizations accountable, and serve as a basis for improvement. The lack of performance data related to values can be compensated by focusing on the behavioral layer of values and extracting quantitative data using event count items (Daneshmandi et al., 2020).

Event count items can partially solve response style bias and, to some extent, eliminate the problem of lacking quantitative data appropriate for LSS. Rather than using a Likert scale, survey questions can inquire about specific incidents or the percentage of time the respondent behaves in a certain way. For example, instead of asking, "I would rather struggle through a personal problem by myself than discuss it with my friends" (Earley, 1993), the survey could ask, "Out of the last five instances you had a personal problem, how many times did you discuss it with your friends?" Similarly, instead of "It is important to him to be polite to other people all the time?" (Schwartz, 2001), which ranges from "not like me at all" to "very much like me," the item could be rephrased as, "In the past two days, how many times have you been polite?" Taras et al. (2009) strongly recommends using event count items (behavior frequency data) as an alternative to self-response questionnaires to improve the validity of findings and reduce bias.

3. Lean Six Sigma Methodology at a School

Several schools, parents, and teachers are involved in students' behavioral problems, which has caused them to become inactive and attribute their shortcomings to each other. The approach of schools and teachers to students' misbehavior often pressures students to leave school, which can only lead to the transfer of these problems elsewhere. Another approach is to tolerate the student alongside unstructured education, the effectiveness of which is never determined due to the lack of measurement systems.

In this study, another approach has been proposed for dealing with students' behavioral problems at a school based on the DMAIC Six Sigma approach, Lean concepts, and SPC. In this case, data was collected at a high school, between November and January 2018 to determine the capability of LSS in the real world. The education team included teachers, support teams (management and support staff), and process engineers who were trained in LSS. The views of students, teachers, and parents were also taken into consideration to verify the results.

Ten values were selected for further study by the education team from the Portraits Value Questionnaire (PVQ) (Schwartz et al., 2001). These values included helpfulness, obedience, self-discipline, politeness, health, social justice (care for the weak), success, devoutness, and environmental protection (Table 1).

Table 1 *Definitions of Ten Values in Terms of PVQ (Schwartz et al. 2001)*

	Value	Description
1	Helpfulness	Willingness to assist others in need.
2	Obedience	Compliance with authority or rules.
3	Self-discipline	Ability to control one's behavior and impulses.
4	Politeness	Respectful and courteous behavior towards others.
5	Health	Concern for physical and mental well-being.
6	Social Justice	Advocacy for fairness and equality in society.
7	Success	Achievement of goals and desired outcomes.
8	Devout	Commitment to religious or spiritual beliefs and practices.
9	Environmental Protection	Concern for the preservation and sustainability of the environment.
10	Altruism	Selfless concern for the well-being of others.

3.1 Define Phase

In this section, the goal of the study is to improve the effectiveness of the VEP, reduce process time, decrease student misbehavior, and enhance the satisfaction of school stakeholders (such as students, parents, and teachers) determined. Additionally, to better understand the process and gain a macro perspective on the process, a macro-level process map or SIPOC is drawn, which includes suppliers, inputs, processes, outputs, and customers. Figure I present the SIPOC for the second high school, in which potential suppliers include the first high schools, other schools, and returning students. Inputs include students from elementary school, teachers, transferred students, curriculum, and support teams. The process involves a series of steps in which students progress through different grades and graduate over a specific time. Customers comprise students, parents, universities, society, and entrepreneurs.

It should be noted that teacher management and support staff play the most crucial role in identifying issues and improving the VEP because they are more familiar with the problems of the educational process than anyone else. However, the opinions of other stakeholders (selected parents and students) were also used to improve the VEP. Utilizing the views of stakeholders at the beginning of the project creates a desire for them to participate in teamwork. To this end, simultaneous with the intensive training of Six Sigma and Lean, the following questions were asked

- What problems and faults do you think there are?
- How do you identify some of the root causes?
- What solutions can you suggest?
- What are the potential outcomes?

The answers to these questions were divided into two categories: educational and non-educational problems, such as administrative processes or construction-related issues. Although this research primarily focused on educational matters, non-educational items were managed, some of which were resolved by an expert (such as complaints about heating systems and low classroom lighting). The problems of value education were also examined in more detail in the analysis phase.

Since one of the main goals of the Lean system is to reduce waste, participants were asked to define waste in the teaching and learning processes of students in the classroom. Table 2 includes identified wastes along with examples. These wastes not only waste people's time and energy but also diminish teacher effectiveness and the quality of learning.

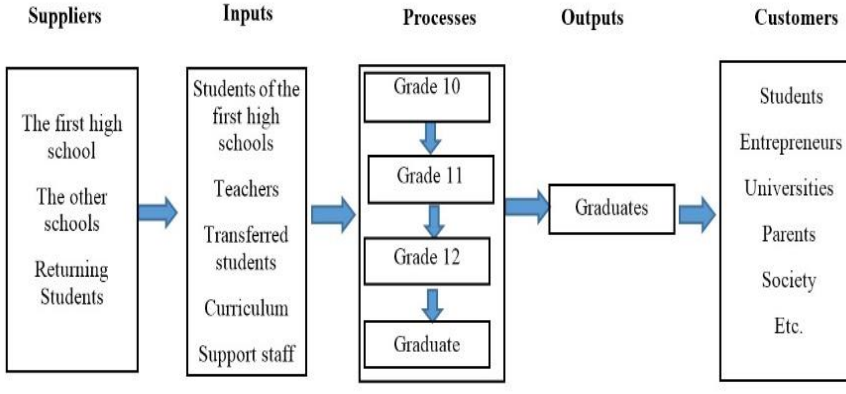

Figure 1: The process of Six Sigma (SIPOC) in a school

Table 2 *Types of Wastes in a Classroom*

Type of Waste	Definition	Example in a classroom
Overproduction	Making more product than customers demand	A lot of training regardless of student's readiness, The mismatch between educational content and useful classroom time
Inventory	Excess products and materials that aren't processed	Teaching useless content
Transportation	Unnecessarily moving products and materials	Carrying a book or accessories that are not in use
Motion	Unnecessary movements by people	The unnecessary movement of teacher and students, unavailability of the required teaching aids
Waiting or Delays	Waiting for the next process step to occur and time spent.	Teacher or student's delay, waiting for equipment to be ready, Queuing for anything, equipment downtime, looking for anything, approval for critical decisions
Overprocessing	Additional processes, or other things that the customer does not need.	Student receives useless content and information which is not needed at all, filling in attendance forms repeatedly
Underutilized people	Underutilization of people's talents, skills, and knowledge	Lack of attention to the abilities and ideas of teacher, parent, students, and other staff
Defects/Rework	A product or service failure to meet customer expectations.	Inappropriate curriculum, insufficient education, Lack of student's focus during the education, Inadequate measurements, Measurement errors, Confusing, educations, Re-training because it wasn't done properly the first time

Recognizing the significance of meeting customers' demands in enhancing the quality of value education, the voices of both external customers (students and parents) and internal customers (teachers, management, and support staff) were identified, as presented in Table 3.

Table 3 *Voice of the Customer for the Process of Value Education*

Customer	Voice of the Customer	Code
Student (S)	In my opinion, the right behavior is difficult. So, I wouldn't say I like to do it (for example, I hate tidying up).	S1
	I don't know how to behave correctly, especially in some situations, making decisions is vague or very difficult for me. Therefore, I'm not sure I can do the right thing (for example, to be tidy).	S2
	I don't know why I should look for the right thing to do.	S3
Teacher (T)	The student does not pay enough attention to the topics presented.	T1
	There is a lot of book content, and I can't teach the values because I don't have enough time.	T2
	The student resists change.	T3
	The basic needs of the student have not been met.	T4
	I don't know how effective each method is.	T5
	Financial problems reduce time and motivation for extra activities.	T6
Parents (P)	Given the many changes, conditions, and facilities, in my opinion, it's time to use newer methods of values education.	P1
	Assignments are so many that the student sometimes does not have time to do the right thing (such as organizing things).	P2
	For a long time, my child has not been asked to do such things, and he basically doesn't feel the need.	P3
	My child does not have enough self-knowledge and self-esteem.	P4
Management and support staff (M)	The current methods are not sufficient for many students because the current situation is not satisfactory.	M1
	Some teachers resist change, and sometimes they do not respect the values themselves.	M2
	Parents do not know how to deal with a student in different situations, and sometimes they do not respect the values themselves.	M3
	It is unknown how the effectiveness of different methods would be.	M4

3.2 Measurement Phase

The measurement phase leads to the formation and recognition of the information flow in the process, contributing to a real understanding of its problems, necessities, and resources. Since the main goal of the VEP is the success of students in behaviors related to different values, the number of errors (nonconformities) reported in different values was considered a key quality characteristic in this process. The educational process is effective only when the number of errors has decreased, indicating an improvement in students' behavioral performance compared to the past.

Most studies in statistical process monitoring assume precise measurements. However, exact measurement is rare in environments where human involvement is evident. Errors due to instruments and operators commonly occur, even with highly sophisticated measuring instruments. Recently, the effect of measurement errors on the performance of various monitoring schemes has been addressed by several researchers such as Noorossana and Zerehsaz (2015), Amiri et al. (2018), and Maleki et al (2017).

To compensate for the impact of measurement errors, a 10-item questionnaire on a Likert scale was used. Questionnaire items solicited parental and student opinions on how the student behaved for each value. They were provided separately to parents and students to meet the independence condition as far as possible. As the normal distribution was not met in the questionnaire, the Mann–Whitney U test was used to

compare the answers. This test compares differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. It is a nonparametric equivalent of the t-student test but examines the equality of medians rather than means. If the answers of the two groups were significantly different, it was concluded that the student or parents' data were likely invalid. Therefore, the students were excluded from the analysis process, and the research continued with other students.

It is noteworthy that the test was performed in a double-blind manner to avoid tension after excluding students. In this method, neither students, parents, nor teachers knew which students were in the research process and which students were excluded from the analysis process. Moreover, this method helped eliminate the chance of conscious bias and distorted information, increasing the test's credibility.

To better focus on values, parental data were integrated for each of the ten values. Figure 2 includes the Pareto chart results, showing that the VEP problems are more significant for self-discipline (V3 or SD) and helpfulness (V1 or HF). This could be due to the large number of behavioral situations on different days, and therefore, the focus should be on their improvement. In general, it is recommended to limit the scope of the Six Sigma project and initially focus on a process that has a significant impact on the organization's core goals.

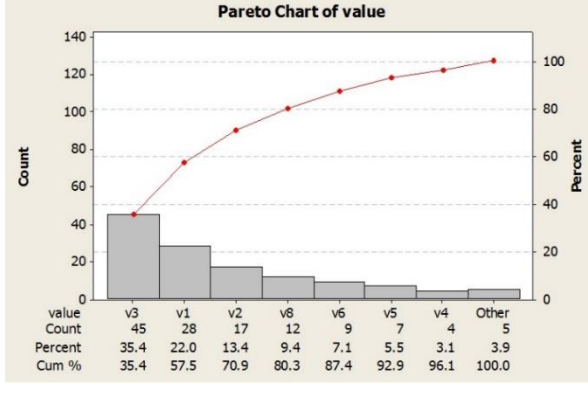

Figure 2 *The Pareto Chart of errors for each Value*

To collect data, the students' behavioral data were gathered for these two values using event count items. The question asked about self-discipline was, "How many times have you exhibited self-discipline today?" Similarly, the question related to helpfulness was, "How many times were you helpful today?" The number of errors (O) and the number of situations (N) were collected for each value using these questions. Over 25 daily samplings, data were derived from the students for the two values of HF and SD.

In the SPC literature, attribute control charts are particularly used for this type of data. There are several widely used attribute control charts. In this research, a standardized U chart was employed for monitoring the number of errors in students' behavior since the sample sizes varied in each sample. This chart is suitable for situations where the average number of nonconformities per unit is a more convenient basis for process control. Figure III displays these control charts for SD and HF, wherein all samples fall within the control limits, and none of the Western Electric rules exhibit non-random deviations.

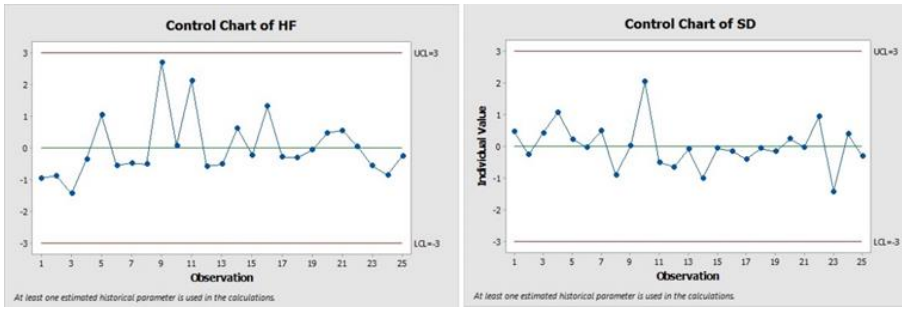

Figure 3 *Standardized Control Chart for Nonconformities per Unit In Phase I*

Given the total error ratio of 0.321 for the HF value and 0.335 for the SD value, the number of faults per million for the two values is about 285,000 at the Sigma 2.08 level, indicating that process improvement is necessary to achieve the desired state.

3.3 Analysis Phase

In this section, the root causes of students' errors are analyzed to identify the required changes to solve the problem. Fishbone diagrams are a common approach to identifying root causes, which can aid in making changes to improve the quality of value education. Several error sources were identified, including students, teachers, parents, books, assessments, methods, school environment, and social environment. Figure 4 illustrates the potential root causes of each of these sources. These root causes were determined through a brainstorming session involving the education team, selected students and parents, and relevant experts.

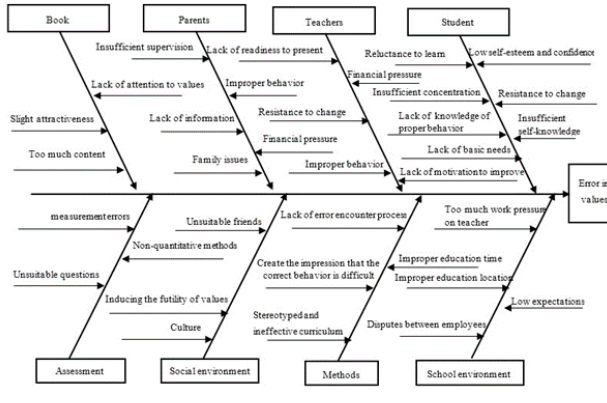

Figure 4 *Fishbone Diagram for the Causes of Misbehavior in Values*

3.4 Improve Phase

After recognizing the root causes and their effect on values in the analysis phase, the corrective actions were introduced to eliminate the causes of misbehavior in values. Table IV presents the corrective actions necessary to improve the VEP, including available solutions to remove errors, and non-value-added activities such as excessive testing assessment that do not provide meaningful insights into student progress or learning outcomes, administrative paperwork that involve redundant or excessive paperwork without directly contributing to student learning or development, unnecessary meetings that are poorly organized, lack clear agendas, or involve participants who do not need to be present, unused resources that are purchased but

not effectively utilized by students or educators, and bureaucratic processes that hinder timely decision-making or responsiveness to student needs. The education team examined the applicability of the solutions and selected the most effective ones. A curriculum was prepared for the SD and HF values. The implicit and explicit education was presented to the students through movies, lectures, books, and other methods in the classroom. Two teachers were selected for this purpose, and each teacher was responsible for teaching a value.

Table 4 *The Corrective Actions Necessary to Improve the VEP*

Process steps	The causes of misbehavior in values	Corrective actions	Relationship with VOC	Responsible
Student	1- Lack of knowledge of proper behavior 2- Improper role models and friends 3- Improper education	1- Teaching parents about the role of appropriate model and friends in student behavior 2- providing new and practical curriculum to teachers	T5, P1, M1, S2, M3	Consultant, Teacher
	1- Resistance to change 2- lack of feeling the need and interest in learning	1- Teaching the importance and benefits of new changes 2- Establishing a connection between one's goals and project goals and expressing the applications of each topic	S1, S3, T3, P3	Consultant, Teacher
	1- Insufficient focus 2- Lack of supplying basic needs 3- Excessive study pressure	1- To provide the basic needs of the student as much as possible 2- Adjusting the educational pressure with the student's conditions	T4, P2, M3	Consultant, Teacher
	1-Low self-confidence and self-esteem 2- Insufficient self-knowledge and Self-acceptance	1- Providing training to parents and teachers to increase student's self-confidence and self-esteem 2- Providing training to students to increase self-knowledge and Self-acceptance	P4, M3	Consultant, Teacher
Teachers	1- Resistance to change 2- lack of feeling the need and interest in learning	1- introducing the importance and benefits of new changes 2- Creating a connection between one's goals and project goals	M2	Management
	1- Lack of readiness to present	1- Introducing new methods and concepts of improvement such as lean to save time and energy	T2, T6, P1, M1	Management

	2- Not using the designed curriculum 3- Lack of motivation to improve 4- Too much work pressure on the teacher	2- Providing incentives to active teachers in using the designed curriculum		
Methods	Improper education time	Allocate sufficient and right time	S1	Teacher
	1- Confusion when a student makes a mistake 2- Lack of error encounter process**es**	Redesigning the process of how to deal with student's faults to apply more accurate methods	M3	Teacher, Consultant
	1- Stereotyped and ineffective curriculum 2- Low attractiveness	Preparing an attractive and effective curriculum	S2, T1, T5, M1, P1	Teacher, Consultant
Assessment	1-Non-quantitative methods 2- vague and wrong questions	Redesign the evaluation process using event count items and SPC	T5	Teacher, Consultant
	1-Low validity of tests 2- Measurement errors	Validation test using Statistical tests	T5, M4	Consultant
Parents	1-Improper behavior 2- Lack of information	Provide training to parents	M3	Consultant
	Insufficient supervision	Provide fast and reciprocal feedback system between parents and school to increase interaction with each other	M4	Management
School environment	1- Too much work pressure on the teacher 2- Low expectations	1-Provide incentives to active teachers 2- helping teachers to extract and enter student and parent data	T2, T6, M2	Management, Consultant

3.5 Control Phase

The control phase serves as a continuation of the improvement phase to ensure its effectiveness. Its goal is to evaluate the plan and solutions and ensure that achievements are maintained through process standardization. In other words, the aim of this phase is to ensure that sustainable development goals are achieved and maintained over time. Control charts provide an effective means to assess process performance and achieve continuous improvement. Figure 5 depicts the control charts for the SD and HF values in Phase II.

These charts indicate that samples fall within the control limits, and no non-random pattern is observed at the top of the control chart. Despite this similarity, the effect of the educational process on students differs significantly between the two. The chart related to the HF value shows a decreasing trend, indicating improvement in students' behavior and the probable effectiveness of the educational process. Points below the centerline denote student progress and the probable effectiveness of the VEP.

In contrast, the SD control chart shows no significant change compared to Phase I. Consequently, the education team decided to investigate the reasons for the process's ineffectiveness. The examination results determined the need for changes in the content of the VEP.

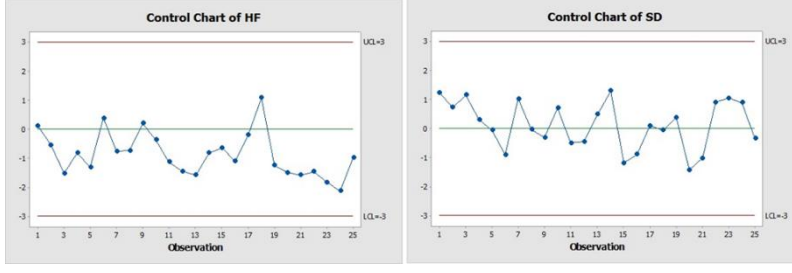

Figure 5 *Standardized Control Chart for Nonconformities per Unit in Phase II*

The education team decided to assess the validity of the control chart using parent data. To compare with previous data, parents were asked about their child's behavior in SD and HF values over the past week. Two statistical tests were conducted to determine whether the educational process is effective from the parents' viewpoint. Table V presents the results of the Sign Test and Wilcoxon Signed Ranks Test, comparing parent data before and after the VEP. These results confirm the findings of the control chart and indicate that the new educational process has been beneficial only for the HF value.

Table 5 *Sign Test and Wilcoxon Signed Ranks Test Results*

	Wilcoxon Signed Ranks Test results						**Sign Test results**	
	HF			SD			HF	SD
	N	Mean rank	Sum of ranks	N	Mean rank	Sum of ranks	N	N
Negative Ranks	9	5.6	50.5	7	6.07	42.50	9	7
Positive Ranks	1	4.5	4.5	5	7.10	35.50	1	5
Ties	4			2			4	2
Total	14			14			14	14
P value	0.013			0.77			0.02	0.77
Z	-2.48			0.2-				

Now that there is sufficient information on the process and its parameters, process capability can be determined to assess the effectiveness of the VEP. Table 6 presents the process capability before and after LSS implementation for each of the values. This table demonstrates that the new educational process has been somewhat beneficial,

particularly for the HF value, as it managed to reduce the total error ratio from 0.32 to 0.23.

Table 6 *Capability of the Education Process before and after LSS*

Value	Phase	Ratio of Total Error
HF	1	0.316
HF	2	0.239
SD	1	0.338
SD	2	0.346

4. Discussions and Conclusions

The implementation of the LSS approach in this study aims to address or mitigate VEP issues. Convincing school management to adopt LSS can be challenging due to a lack of experience and knowledge in the method among most school staff. To generate interest in LSS, concepts were taught, and successful projects were presented to underscore its benefits. It was emphasized that quality improvement, achieved by eliminating waste and errors, is essential for meeting customer expectations.

Identifying the expectations of the most crucial customer—the student—poses a challenge, given the issue of maturity. Immature students may prioritize entertainment over learning, while mature individuals understand the importance of education in facing future challenges. To address this, the educational process is developed based on the expectations of mature students, or at least those that students are expected to become. Parental data, being closest to student maturity, was utilized for appraising measurement errors.

The DMAIC approach's definition phase identified the project's purpose, macro-level process map, and classroom waste types. Customer voices were identified to meet their demands, recognizing the unique challenges of educational environments, including resistance to change due to teachers' autonomy and individual perspectives. Linking project goals to employee objectives fosters support and reduces resistance to change, as staff understand its alignment with the school's strategic goals.

In the measurement phase, focus was placed on two key values (SD and HF), demonstrating value creation to customers through Six Sigma projects. Student behavioral data for these values were collected, and control charts were used to assess the current state of the process. The analysis phase employed fishbone diagrams to identify root causes of behavioral issues, revealing various challenges within the school system.

During the improvement phase, solutions were implemented, such as curriculum standardization and specialized training for teachers and parents. Strategies to enhance student confidence and self-esteem were introduced, alongside improvements in error handling processes. A feedback system between parents and the school was established for improved communication.

The evaluation process was redesigned using control charts and validation tests with parental data. School management supported teachers by assisting in data management tasks. However, the results showed limited effectiveness in improving the SD value, signaling the need for corrective action.

It's crucial to acknowledge that corrective actions address some, but not all, root causes of the problem. Teachers and the educational process are influential factors in student behavior, and ongoing support for teachers is essential for continuous improvement. However, expectations remain that teachers uphold student values to foster a positive learning environment. It is important to point out that although data

was collected prior to Covid-19 pandemic, since the educational process and value creation remains unchanged, we expect the results to be equally applicable to the post Covid-19 period.

The authors believe that since Lean Six Sigma methodology is a well-designed methodology with many valuable tools applicable to different situations. It is expected that one can easily apply LSS to higher education and training programs to identify root-causes contributing to value creation process to make improvements.

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