Sustainable development model for maritime training and education using the Six Sigma approach

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Abstract

The existing international shipping regulations require effectiveness measures that are carried out at all levels within training institutions. The Six Sigma approach could thus be utilized by IAMU member institutions for performance improvement and approaching excellence in training and education services. The core commitment to institutional capacity enables the MET institution to consider resource issues from a holistic perspective, and to consider capacity as an institutional attribute beyond the minimum compliance and a review of assets. Looking at itself through a "lens" of institutional capacity enables the MET institution to re-examine what it is in terms of its capacity to fulfil its aspirations, and to integrate and synthesize findings and recommendations for improvements gained through its self review. This paper illustrates the advantages and techniques of the Six Sigma approach that could be directly applied for quality improvement at IAMU member institutions while simultaneously integrating those requirements of the international conventions adopted by the International Maritime Organization.
Keywords: Six Sigma, training quality, MET institutions, safety management, effectiveness improvement.

1 Introduction

For the assurance of maritime safety and environmental pollution prevention objectives, the STCW 95 Code requires quality standards for all training institutions in accordance with regulation I/8 IMO [1]. The existing regulation

requires that effective measures should be carried out at all levels in the training institutions. The main objective of the quality standard is to train and certify the crew members in an efficient, continual improvement approach complying with the requirements of IMO Conventions such as SOLAS, MARPOL, STCW, COLREG, LOADLINE and ILO amendments.

It is obviously seen that the quality assurance of a MET institution becomes much more complicated when safety, environment and quality management criteria need to be integrated into the existing dynamic processes of a training institution while defining the knowledge, understanding, skills and competence. The assessment activities of all MET institutions' management and operational levels on a worldwide basis result in another crucial constraint caused by different national backgrounds. In the competitive atmosphere of MET institutions' processes, the Six Sigma approach is proposed in this paper for IAMU member institutions that are seeking excellence in maritime training and education.

2 Six Sigma

Six Sigma is a concept that was originated by Motorola Inc. in the USA around 1985. At that time, they were facing the threat of Japanese competition in the electronics industry and needed to make drastic improvements in their quality levels [2]. Six Sigma was a way for Motorola to express its quality goal of 3.4 defects per million opportunities (DPMO) where a defect opportunity is a process failure that is critical to the customer. Motorola set this goal so that process variability is ±6 standard deviation from the mean [3]. They further assumed that the process was subject to disturbances that could cause the process mean to shift by as much as 1.5 standard deviation off the target; Montgomery [4]. Factoring a shift of 1.5 standard deviation in the process meant then results in a 3.4 DPMO [3,4]. This goal was far beyond normal quality levels and required very aggressive improvement efforts. For example, 3 sigma results in a 66,810 DPMO or 93.3% process yield, while Six Sigma is only 3.4 DPMO and 99.99966% process yield (these computations assume a 1.5 standard deviation shift in the process mean). It should be noted that there is no need to operate all the processes at the Six Sigma level. The appropriate level will depend on the strategic importance of the process and the cost of the improvement relative to the benefit.

If a process is at the two or three sigma level, it will be relatively easy and cost effective to reach the four sigma level. However, to reach five or Six Sigma will require much more effort and more sophisticated statistical tools.

The effort and difficulty increases exponentially as the Process Sigma increases. Ultimately, the return on investment for the improvement effort and the strategic importance of the process will determine whether the process should be improved and the appropriate target sigma level as a goal.

Six Sigma can be defined as an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in

customer defined defect rates. This definition highlights the importance of improvements based on the customer's definition of a defect.

A key step in any Six Sigma improvement effort is determining exactly what the customer requires and then defining defects in terms of their "critical to quality" parameters. From a goal setting perspective, Six Sigma advocates establishing goals based on customer requirements, not on internal considerations. Using customer requirements is certainly not something that is unique to Six Sigma, but it is important from a goal theory perspective. Six Sigma also uses unique metrics including Process Sigma measurements, critical-to-quality metrics, defect measures and improvement measures [5,6]. One of the first steps in the improvement process is to measure the current Process Sigma.

Six Sigma uses a structured method, whether the task is process improvement or new product design. In the case of process improvement, the method is patterned after the plan, do, check, act (PDCA) cycle [7]. One popular method uses define, measure, analyze, improve and control (DMAIC) as the five steps in process improvement. A somewhat different set of steps called Design for Six Sigma is used for radical or incremental product design (define, measure, analyze, design and verify). Whatever method is chosen, however, it is important that the method be carefully followed and a solution not offered until the problem is clearly defined. Data and objective measurement is critical at each step of the method. The standard statistical quality tools are incorporated into the structured method as needed. Finally, Project Champions who identify strategically important projects for the improvement teams and provide resources, typically receive an orientation to Six Sigma rather than detailed training.

3 Application model for MET institutions

3.1 Identification of principle boundary conditions

The training and education concept can be analyzed in four categories for determining the general expectations and reaching the customer satisfaction philosophy.

a. Knowledge, which enables people to understand what they learn in relation to what they already know [8]. Knowledge is both practical and theoretical. Theoretical knowledge provides people with the ability to generalize from unique instances. With theoretical knowledge, people can accumulate many years of experience; such as twenty years. Otherwise, with only practical knowledge, people will have only one year repeated twenty times.
b. Know-how, which enables people to do. Know-how takes people past merely understanding. Know-how enables people to put knowledge to work [8]. Know-how differs significantly from knowledge. Knowledge can be organized into intellectually tight compartments, and these compartments may be taught as a subject unto themselves. Know-how, on the other hand, requires the purposeful organization of knowledge

from many different areas of learning. As know-how is extended to higher and higher levels of accomplishment, it requires extension to more and more areas of knowledge. When teaching know-how, it is impossible to put bounds on the areas of knowledge that will be encompassed.

c. Wisdom is the ability to distinguish what is important from what is not; [8,9]. Wisdom enables people to set priorities on how to use the resources of time, energy, and emotion.

d. Character, as Covey has said, is a combination of knowledge, know-how, and wisdom coupled with motivation [8]. People often recognize the development of character by certain character traits, among which might be listed: honesty, initiative, curiosity, truthfulness, integrity, cooperativeness, ability to work alone, ability to work in groups, self-esteem. It is up each MET institution to identify what to include in each of these four categories. It appears that in maritime education and training, attention is given only to the first of the four categories, with the last two not even given lip service. In maritime education the lecturers often believe that at the university level their sole duty is to develop knowledge and pass it on to the next generation. The development of a student's character is none of their business.

Coupling concept with Six Sigma

In this study the utilization of the Six Sigma model is proposed consisting on the institutional objectives, core functions, and organizational structures for ensuring sustainability and the evaluation method for effectiveness.

This study offers various levels of competency categories on a worldwide basis for maritime training institutions, as it is also required by the STCW Convention. The various competency categories will be as follows:

- For maritime training institutions, that seafarer's competency below 500 GRT and 750 kW in accordance with the STCW 95 regulation II/3, III and the additional administration's requirements.
- For maritime training institutions, that seafarer's competency between 500 and 3000 GRT, 750 and 3000 kW in accordance with the STCW 95 regulation II/2, regulation III/1 and III/3.
- For maritime training institutions, that seafarer's competency above 3000 GRT and 3000 kW in accordance with the STCW 95 regulation II/1 and II/2, regulation III/1, III/2.
- For training institutions that their graduates are employed on board the ship as support or assistant staff and officers like radio operator/officer, radio-electronic officer, electrician, electric/electronic officer, medical officer, steward, cook, amateur seaman etc.
- For training institutions, that their graduates are employed in shore based organizations.
- Ship Management Companies (superintendents, operation, technical, crewing and fleet managers).
- Docking and Ship Repair Companies.
- Ports and Terminals.

- Chartering and Brokerage Companies, agencies and other miscellaneous fields of industry that serve the shipping business.

Hence, as the Six Sigma approach focuses on customer requirements, it is better to define who is the customer of the MET institution and what are the expectations of the customer. In this consideration the relationship between supplier and customer, and in addition the product that is provided by the MET institution, could be defined as follows.

Actually the maritime student is not a product. The product is the education of the student. In the manufacture of this product, as with any other product, it is essential that the worker (student) be an active participant in the design and creation of the product. The student, who is the person who stays with the learning process longest, should learn to become the co-manager of his or her education. This means, according to the tenets of quality management, that the student should be involved, consciously and with skill, in the continuous improvement of the processes that create the product.

The customers for the education of the maritime student are several. These are, in order of importance:

1. The maritime student, who must live with the product for the rest of his or her life. The student must become the co-manager of the production of the education and, having such a personal stake, must be considered first when attempting to define what it means to have quality in education.
2. The maritime student's parents and immediate family who, in many instances, are paying for the product and might also live with the results for the rest of their lives.
3. Potential employers who will rely on the education of the student after graduation to achieve the purposes of their enterprises.
4. Society at large, which pays a substantial proportion of the cost of the education and requires the future participation of the student as a citizen in the operation of government, as a contributor to the general welfare of society, and as a taxpayer who will support the education of future generations of students.

After defining the basic interrelationship between product and customer, it is necessary to define the special boundary conditions of MET. In the shipping business the management of training and education can be considered as the technical and the commercial management of maritime activities. The new regulations or rules that will be established by IMO have to be taken into account as research work and the requirements of new rules have to be amended in relevant department curriculums in an efficient manner. As well as the Port State Control parameters, the effects of these parameters in the shipping environment cause rapid, positive changes in the improvement of ship management. As a result a lecturer's academic research has to point out port state control inspection results and the classification society's survey requirements that complies with the statuary certification of vessels. From the Commercial side of ship management, the charterers' complaints and the condition of clauses in the

charter party directly affect the claim handling process. The marine casualties or cargo damages that have a direct significant impact in training needs must be considered.

In order to overcome the above constraints the utilization principles of Six Sigma into the management system of a MET institution is summarized in Table 1.

Table 1: Utilization principles of Six Sigma for MET institutions.

What Six Sigma will provide MET Institutions?
Confidence to : - the students, maritime industry, government and society - the faculty management that the requirements for quality are continuously met
An effective marketing tool
Unambiguous definition of the responsibility and authority of all persons involved in teaching, learning, research including: professors, teaching assistants, students, administrative staff, technicians and support staff
For the adequate determination of the customer requirements for quality
For the continuous information monitoring and feedback system
Adequate documentation of the program, course design activities and output
Adequate documentation of the student entrance requirements, hiring/ employment of new staff and material
Identification and traceability of all records, students, courses, research progress
Ensure that there are procedures available for control of the teaching, learning, research processes, including: reliability of laboratory, computer, library equipment, simulators, student counselling as well as continuous feedback to the student
For the adequate documenting procedures for conducting and reporting the results of all tests, assessments, exams, quizzes including graduation
Adequate documentation of academic advancements, merit awards and/or non-conformance
Adequate control of student, staff and research failure
Internal quality audits, management reviews
Adequate use of statistical techniques

When we focus on Safety Management courses in MET institutions, it is necessary to identify the Safety Management System of shipboard operations and the significance of the ISM Code appears only slightly [10]. While the ISM Code consists of safety and environmental pollution prevention procedures [11] the STCW Convention covers the competence of shipboard personnel, and the Six Sigma covers the DMAIC approach requirements that enable a MET institution to design core Safety Management System courses in an appropriate manner. For this reason the integrated requirements' application for the Safety Management System course concept is defined below to enable a baseline for the design process.

There are many links between the ISM Code and Six Sigma as a project management tool. Defining the elements in the Six Sigma approach constitutes structures and responsibility and course program layout and curriculum

establishment procedures. In the active learning approach, the ISM Code found it more practical to define such responsibilities in separate sections such as the safety and environmental protection policy (clause 2), company responsibility and authority (clause 3), designated person(s) (clause 4), master's responsibility and authority (clause 5), resources and personnel (clause 6), verification review and evaluation (clause 12). Clause 7 of the ISM Code corresponds to the following elements of the Six Sigma approach such as the elements of "measuring" and "analysis". Clause 8 of the ISM Code corresponds directly to emergency preparedness and response matters that need to be involved in the "define", "analyze" and "improvement" elements of the Six Sigma approach. Clause 9 of the ISM Code, although it covers a wider field of shipboard operations, matches the "measurement", "improvement" and "control" elements of the Six Sigma approach. The concerns of clause 10 of the ISM Code are divided into the monitoring and measurement, and operational control elements of the Six Sigma approach. Similarly the concerns of clause 11 of the ISM Code could be interpreted under the element of "define" for the safety management system documentation, document control and records traceability in the Six Sigma approach. Clause 12 of the ISM Code corresponds to the "improvement" and "control" elements of the Six Sigma approach.

More detailed links between the ISM Code, and the elements of the Six Sigma approach are given in Table 2; Er and Furusho [12].

Table 2: Links between ISM Code and Six Sigma considerations.

Active links between the ISM Code & Six Sigma	**Define**	**Measure**	**Analyze**	**Improve**	**Control**
2. Safety & Environmental Protection Policy	■		■	■	
3. Company Responsibility & Authority	■		■		■
4. Designated Person(s)	■				
5. Master's Responsibility and Authority	■				
6. Resources and Personnel		■	■	■	■
7. Development of Plans for Shipboard Operations		■			
8. Emergency Preparedness	■		■	■	
9. Reports & Analysis of Non conformities, Accidents		■		■	■
10. Maintenance of Ships & Equipment		■	■		■
11. Documentation	■				
12. Company Verification, Review and Control				■	■

Similarly the comparisons between the ISM Code, STCW Convention, MARPOL Convention and Six Sigma approach as a project management tool are given in Table 3. The STCW Convention stipulates in some detail that MET institutions must be able to demonstrate that the relevant STCW provisions have been implemented to ensure that the aims of the convention are met, i.e. that

seafarers employed on board are competent, qualified and can indeed perform their duties safely and effectively.

Table 3: Comparison of ISM Code, STCW, MARPOL and Six Sigma.

	ISM Code	STCW Convention	MARPOL Convention	6σ for MET Institution
Field of Application	Management of safety at sea and pollution prevention	Training, certification and watchkeeping	Prevention of pollution from ships	Improvement of existing management system performance, minimizing defects
Applicable to	Ship Management	Administration, training services, MET institutions, ship management companies and shipboard operations	Shipboard operations for all types of ships	All MET institutions that wish to implement realistic based quality improvement
Purpose: Demonstrate compliance with	Managing safety and pollution prevention	Training, certification and watchkeeping requirements	Reducing the risk of pollution form ships	Self declaration of conformance
Means: Implemen-tation of	Safety Management System	Training Management System	Pollution prevention regulations and rules	Integrated System approach for project management
Scheme of certification	Shore based audit and shipboard audit	Organization's Audit	Flag State survey program	NIL
Validity	5 years subject to audit	5 years subject to assessment	5 years subject to surveys	NIL
Compliance	Mandatory	Mandatory	Mandatory	Voluntary

4 Conclusion

Appropriate implementation of the Six Sigma project management approach elements within the parallel view of international shipping rules and regulations can enable MET institutions to undertake planning and evaluation appropriate to their needs to accomplish and improve the achievement of their missions and purposes. In this respect MET institutions shall undertake both short-term and long-term planning including the candid and realistic analyses of internal and external opportunities and constraints. It shall respond to financial and other contingencies, establishing feasible priorities, and developing a realistic course of action to achieve the identified objectives that are defined in IMO Conventions. Institutional decision-making, particularly the allocation of

resources, shall be consistent with planning priorities. The MET institution shall systematically collect and use the data necessary to support its planning efforts and to enhance institutional effectiveness.

Thus, through its organizational design and governance structure, the MET institution can create and sustain an environment that encourages teaching, learning, scholarship, and where appropriate research, and it shall assure provision of support adequate for the appropriate functioning of each organizational component or department. In this consideration the MET institution can periodically evaluate the effectiveness of its system of governance using the results of statistical data that are obtained due to the strategic planning phase in the means of self-assessment. The advantage of the Six Sigma tool can enable the MET institution's activities by controlling the process as a backward and forward data-driven process. This means the actions will be taken step by step. The steps will define the aspects, analyze the impacts, measure the significant impacts, and then tailor a solution that could be named as the target.

While focusing on educational effectiveness, articulating a collective vision of educational attainment, organizing for learning and becoming a learning organization milestone can easily be incorporated within Six Sigma.

Articulating a collective vision of educational attainment centres on the degree to which the MET institution sets goals and obtains results for student learning at both the academic and program levels; these are:

- clearly stated and widely understood;
- appropriate for the type and level of the degree or credential offered; and adequately assessed to ascertain mastery of these levels.

Organizing for learning centres on the alignment of appropriate MET institutional assets and characteristics with the goal of producing high levels of student learning, consistent with the mission of the MET institution; these include:

- curriculum, pedagogy, and method of delivery;
- faculty recruitment, development, scholarship in support of improved teaching and learning, rewards, and incentives;
- organizational structures and processes;
- information resources and planning capacity;
- student services and co-curricular activities; and
- resources and facilities.

Consequently becoming a learning organization centres on the degree to which the MET institution has developed systems to assess its own performance and to use information to improve student learning over time that:

- are systematic and regular;
- reinforce a climate of inquiry throughout the institution;
- reflect the input of stake-holders and an awareness of the distinctive characteristics of its students;
- identify key dimensions of performance that include student learning and
- are based on standards of evidence that prominently feature in the educational results.

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