Applying Lean Thinking For Effective Utilization of Resources in Education Sector

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***Abstract*— Lean thinking is a methodology to organize human activities to improve efficiency and effectiveness by eliminating waste. Apart from the manufacturing sector, its application in the service sector is gaining momentum in recent years. However, only a few studies were carried out for implementing lean in an educational institute. This study aims to apply lean thinking for the identification and minimization of various wastes in an educational institute. After a review of the relevant literature, various processes in the institute were studied, potential sources of wastes are identified, and its effects were quantified based on cost, space, and ease of work. Solutions for the identified problems are proposed, and implementation was carried out followed by a gap analysis. The findings revealed improved workflow and a substantial decrease in waste and unwanted motion.**

***Keywords*— Lean thinking, service sector, education, implementation, work flow**

I. INTRODUCTION

In the mid-1950s the Japanese developed the ' Lean ' theory. Lean focuses on stabilizing and standardizing processes so that critical issues are apparent and the staff builds critical thinking skills to resolve the issues and enhance workflow. In the last two decades, lean methods have been used effectively in manufacturing (Alsmadi et al. 2012). Lean implementation in the manufacturing sector has been very successful. Service industries have recently gained much importance. Such service industries increasingly follow lean methodologies to boost their performance in the delivery of top quality services.

Lean thinking requires an understanding of the concept of continuously identifying ways to reduce waste through the implementation of lean customer satisfaction tools and techniques (Schiele and McCue, 2011). Service companies must fulfill each customer's unique needs in order to always be ahead of their competitors.

The education sector in India is changing rapidly. Educational institutes aim to provide their students with more attractive offerings. It is doubtful that anyone could foresee where the sector of education will go in the coming years, but one thing is certain (Barber et al., 2013): institutes will do more with less, develop new teaching and learning approaches, distinguish them through a distinction among the products and services it provides, give students a greater value-adding proposition and continue to focus more on 'customer'. To achieve the above targets, therefore, educational institutes must become more lean and effective in what they are doing and this will inevitably call on them to adopt development techniques, such as Lean, to help them achieve an economically sound and more efficient organization.

Implementing strategies for business development such as Lean, Six Sigma, etc. poses its own challenges. Antony et al. (2012) identified a number of key problems in the Lean Six Sigma implementation at Higher Education Institutes. Their research explains that the "leanness" strategy for a significant number of senior managers remains elusive, mainly due to: a lack of awareness of Lean's advantages in the non-manufacturing industry; a lack of engagement and encouragement from executive teams make it difficult to promote a culture of continuous change.

However, while there are many challenges and barriers, benefits that can be achieved are many. Radnor and Bucci (2011) identified a promising set of results emerging out of Lean implementation. These include improvements in culture in specific areas of the HEIs, where workers have grasped the Lean idea, recognizing that Lean has provided them with the capacity to come up with efficient solutions and encouraging employees to take key decisions and change their business processes; allowing institutes to deal with quick gains and deliver immediate repercussions that allow workers to look at the enhancement of other systems; allows employees the opportunity to engage in process improvement exercises centered on internal processes.

With regard to the general question of the Lean Implementation in educational institutes, the amount of academic literature that is currently available is less.

This paper addresses this issue by implementing lean thinking for elimination of various wastes in an education institute and adopt continuous improvement.

II. LITERATURE REVIEW

Literatures relevant to application of lean in various service sectors are collected and its implications are discussed below:

Dr. Paulette S. Alexander, et.al (2017) have highlighted the use of VSM to improve MBA recruiting processes. They formed a cross functional team and implemented VSM tools focused on improving prospective student engagement. The team learned that consistent emphasis on the "future state" is more motivational to them than placing blame for the "current state". The implementation resulted in resulted in improved enrolment such as an average 70% enrolment increase.

Mark Robinson, et.al (2014) created their own methodology "The St Andrews Model" and discussed on how lean can be implemented in higher education. They insist that no one methodology can suit another institution and hence each institution should frame their own model.

Warren W. Fisher, et.al (2011) applied VSM tool to improve the academic advising processes in a large department of a major university. Study of the current state VSM map has resulted in several improvement suggestions, and analysis of the revised VSM diagrams shows the potential for significant improvement in services to the customers (students) and in the activities of the service providers (staff). This research has shown that VSM can be successfully applied to services related to higher education.

STANCA (2002) presented how the most important quality related concepts such as quality control, quality assurance and total quality management can be applied in education. An comparative analysis is made on ISO 9000 standards and prepared a proposal for MET, called METAS. Achieved better cooperation among MET institutions.

Zoe Radnor, et.al (2011) analyzed the effect of implementation of lean in various business schools in UK. Implementing Lean had significant impacts like improving the culture of change, revising processes and practices and staff improvements concerning their work. It is stated that the revised processes were one of the key successes of the Lean programmes, which would be sustained even if the Lean programme ended.

Lejla Brouwer-Hadzialic, et.al (2016) focused on use of Value Stream Mapping (VSM) to depict teaching process. Due to the high level of co-production and rich informational nature of teaching, traditional VSM falls short when graphically presenting the value stream in teaching. Service blueprinting is a good alternative to VSM for graphically modelling the teaching process.

Stephan Höfer, et.al (2017) in their research, aimed to show how the lean strategy can be applied in university environments. Five key lean principles were presented and examples of their implementation were discussed using short case studies from the institution. They showed that Lean implementation requires a commitment on the part of the university top management.[7] The above literatures show how lean implementation was possible in the higher education sector.

Ravi Chourasia, et.al (2016), in their study, proposed that Service sector contributes 52% GDP in Indian economy. The study concluded that efficient use of 5S in an organization provides a safe environment, optimal utilization of space and leads to improved quality. The results indicated that various service industries such as hospitals, hotels, banks and higher education have utilized the principles and tools of lean to increase their competitiveness.

Gopalakrishnan Narayanamurthy, et.al (2017), in their another research, developed a framework describing the procedure for implementing Lean Thinking in an educational institute. By adopting Action Research Methodology (ARM) for a time period of 28 months, they showed that the number of unfilled seats (poor utilization) in an elective course in the second year of the program drastically reduced.

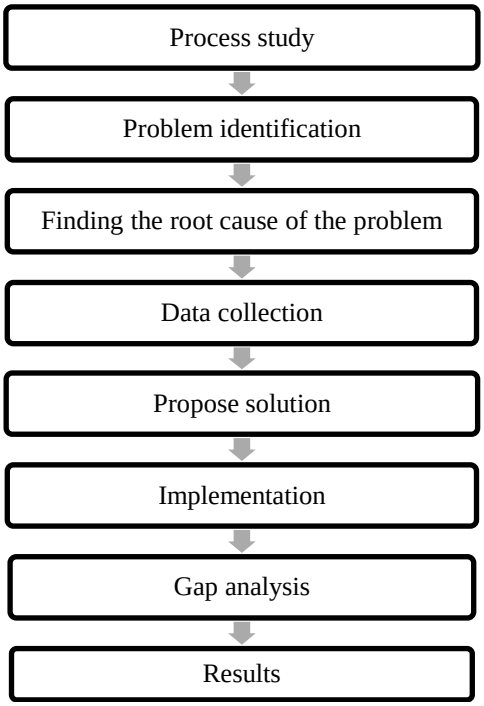
Punnakitikashem, et.al (2012) successfully implemented in healthcare using SERVQUAL (Service Quality) model, which had 5 distinct service quality dimensions of healthcare. Various other powerful lean tools, continuous application of 5S Principles and Mieruka (Visual Control) aided in the achievement.

Charles R. Gowen, et.al (2012) made a study on the effects of Continuous Quality Improvement (CQI), Six Sigma and Lean Management Initiatives . Lean tools 5S, Value Stream Mapping (VSM), Kaizen and JIT (Just In Time) proved to be significant in reducing waiting times and costs of medical wastes. They achieved improved patient safety results, owing to the ease of learning and implementation of Lean tools, and their immediate results.

Jiju Antony, et.al (2012), in their research, discussed on the methodology Lean Six Sigma (LSS). This methodology promised enhanced customer satisfaction and improved bottom-line results. Most of higher education institutions are far behind in usage of this methodology. Tools and techniques to implement LSS included VSM, Cause and Effect Analysis and Visual Management and required top management support and commitment, visionary leadership and effective communication.

Thus it is evident that lean tools and techniques like Lean Six Sigma, VSM, Cause and Effect Analysis and Quality Control Tools can be used to implement lean management in any institute belonging to service sector.

III. METHODOLOGY



IV. EXPERIMENTATION

A. Problem Identification

The various key processes of the entire educational institute have been studied. For each process, a basic process flow chart has been developed to help to identify the bottlenecks in the processes.

As a result of a thorough study, waste for non-value adding activities was reported at the single semester level for each of the sub-processes defined. The various types of waste found in each sub-process are mentioned in Table I. The seven wastes proposed by Taiichi Ohno has been put into perspective within the field of education sector.

TABLE I
Various Wastes In The Processes

	ASSIGNMENTS	INTERNAL TESTS	PROJECT	APPROVALS	TRANSPORT BOOKING	HALL BOOKING
OVERPRODUCTION						
INVENTORY	✓	✓	✓			
WAITING			✓	✓	✓	✓
TRANSPORTATION		✓				
OVER PROCESSING					✓	✓
MOTION	✓	✓	✓	✓	✓	✓
DEFECT						

In order to identify the root causes of the problems mentioned above, a cause and effect diagram is drawn which is shown in Fig. 1. It is further analyzed to prioritize the problems and come up with an effective solution.

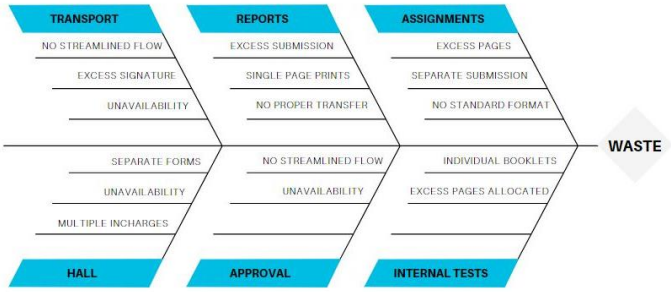


Fig. 1 Cause and Effect Diagram

B. Data Collection

From the cause and effect diagram it is observed that reports and test papers contribute most of the inventory waste. Hence in order to reduce the inventory waste and propose suitable solution, different samples of various inventories were taken and it's data is noted down for further analysis. The findings are given below.

1) Project Reports:

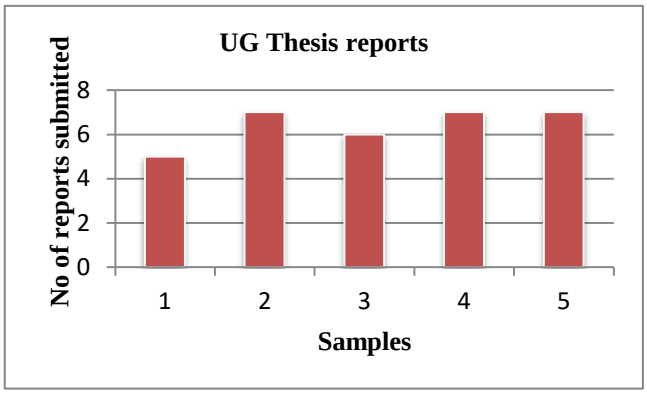


Fig. 2 Data of UG thesis reports

Average number of UG thesis reports submitted in a academic year = 180

Average cost spent by a student for UG thesis reports = Rs.229

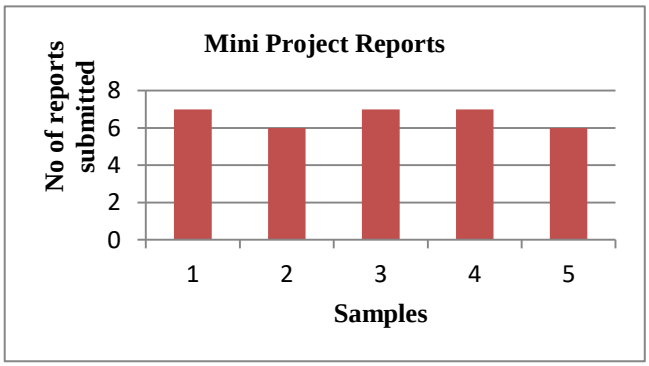


Fig. 3 Data of mini project reports

Average number of mini project reports submitted in a academic year = 180

Average cost spent by a student for mini project reports = Rs.160

From the data collected it is identified that project reports contribute waste both in terms of space and cost incurred to students whom are considered as customer in an educational institute.

2) Test papers:

In test papers, it is observed that excess pages are being allotted for 50 mark and 100 mark booklets which is not utilized by the student and goes to scrap as a waste. This contributes in inventory and motion waste, and hence an alternate solution is required.

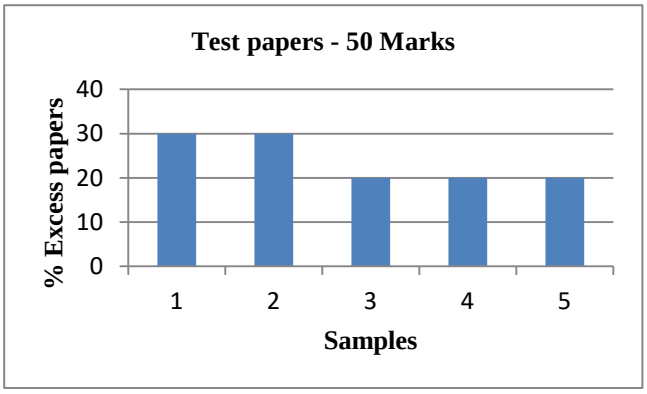


Fig. 4 Data of 50 mark test papers

Average percentage of excess papers in a 50 mark booklet = 24%

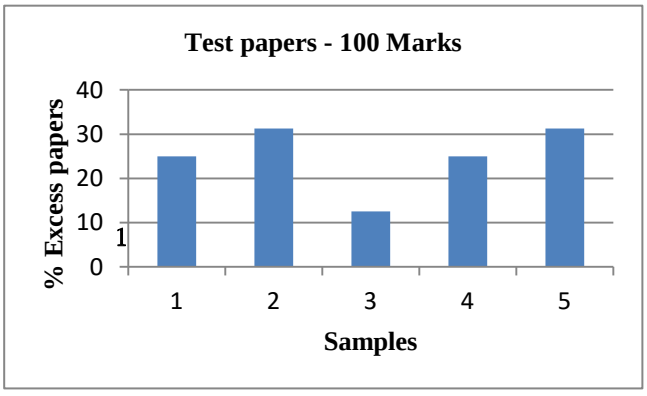


Fig. 5 Data of 100 mark test papers

Average percentage of excess papers in a 100 mark booklet = 25%

C. Validation

Ideas to eliminate the above mentioned inventory wastes are generated. For any lean project, it is essential validate the plan for a successful implementation. Validation of the lean project serves a strong role in ensuring the success of the project. For the project considered, hypothesis testing of statistical data was chosen as the method of validation. The inventory (paper samples) were considered for hypothesis testing. Since the input and output data types are of discrete form, Chi-Squared Test was chosen as the method of hypothesis testing. The Chi Square statistic is commonly used for testing relationships between categorical variables. The null hypothesis of the Chi-Square test is that no relationship exists on the categorical variables in the population; they are independent and implementation will have no significant difference[17]. The alternate hypothesis is that relationship exists on the categorical variables in the population; they are dependent and implementation will have a significant difference. The Chi-Square statistic is given by the formula:

$$\chi 2 = \sum \frac{(fo - fe)^2}{fe}$$

where, fo = the observed frequency (the observed counts in the cells) and fe = the expected frequency

The null hypothesis is rejected when the statistics in the hypothesis testing obey the following conditions:

$$\text{p-value} < \alpha$$

$$\chi 2 \text{ (Critical)} < \chi 2$$

where, α – Level of Significance, p-value – Probability value, χ2 (Critical) – Critical value of the chi-square statistic, and χ2 – Chi-square statistic

Null Hypothesis (H_0) : There is no significant difference (after implementation)

Alternate Hypothesis (H_1) : There is a significant difference (after implementation)

For the case considered for validation(inventory), 15 samples were taken for hypothesis testing and the test values were mentioned in Table II. As a result of testing, the following statistics were obtained.

A = 0.05

Df = 14

p-value = 0.00000096292

χ2 = 54.73099415

χ2 (Critical) = 23.6847913

Since p-value<α and χ2 (Critical) < χ2, H_0 is rejected.

Hence, there is a significant difference (after implementation)

TABLE II
CHI-SQUARE TEST

Category	Observed	Expected	$\frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$
Sample 1	51	68.4	4.426315789
Sample 2	76	68.4	0.844444444
Sample 3	54	68.4	3.031578947
Sample 4	74	68.4	0.458479532
Sample 5	82	68.4	2.704093567
Sample 6	71	68.4	0.098830409
Sample 7	67	68.4	0.028654971
Sample 8	74	68.4	0.458479532
Sample 9	69	68.4	0.005263158
Sample 10	104	68.4	18.52865497
Sample 11	50	68.4	4.949707602
Sample 12	92	68.4	8.142690058
Sample 13	63	68.4	0.426315789
Sample 14	52	68.4	3.932163743
Sample 15	47	68.4	6.695321637
	Total = 1026		$\chi 2 = 54.73099415$

D. Implementation

After the validation of data collected, the generated ideas were implemented. Some of the solutions implemented are detailed below.

1) Project Reports

In the existing process, project reports(hard copies) were submitted in multiple quantities for the purpose of documentation and future reference in department and library. Hence the changes are made such as only one hardcopy is to be submitted and for future reference in library, soft copies are collected, stored as a combined file in a PC specifically allotted for student development in the library. Backup copy is also made available by storing it in a pendrive which is preserved at library.

2) Test Papers

There are 3 booklets of test papers currently been used for 3 internal tests. It resulted in more paper waste and excess motion in each tests. Hence, a single booklet format was prepared with optimum number of pages for all three internal tests. The format was finalized and implemented for upcoming tests.

A significant reduction in motion waste and inventory is noted as an outcome of implementation. The ease of work for staffs in case of internal audits were also improved.

3) Assignments

In the existing system, the students are required to buy required A4 sheets for each of 3 assignments in a semester, complete the allocated assignments and submit it to the respective faculty. This results in excess inventory, motion and most importantly underutilized human resource due to traditional way of completing the assignments.

Hence, new forms of assignment such as solving a program in a software, online quiz, taking seminar, e-assignments, etc., are given to the students. Apart from reduction in inventory and motion, it was found that the active involvement of students in assignments were increased significantly and it also indirectly paved way for personality development of students.

4) Transport Booking

In case of a transport facility is needed for any purpose, the faculty/student is required to undergo the process mentioned in Fig. 6.

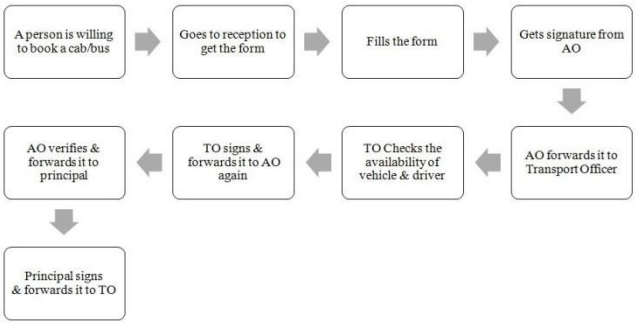


Fig. 6 Transport booking process - Existing

The existing process is tedious for the booking person and involves lot of non-value added (NVA) activities. Therefore a new process is proposed and implemented as mentioned in Fig. 7.

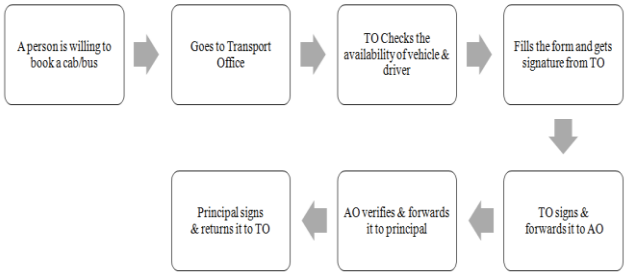


Fig. 7 Transport booking process - New

5) Hall Booking

The organizer (student/faculty) of an event is required to undergo the process mentioned in Fig. 8, in order to book a hall.

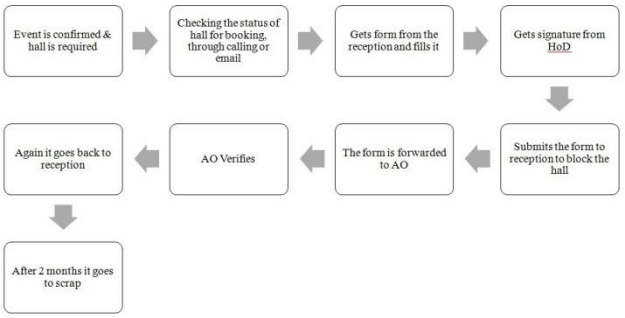


Fig. 8 Hall booking process - Existing

This process also involve NVA activities such that it contributes to waste. Hence, a single faculty is assigned as a in-charge of a particular hall and hence authorization from the respective in-charges alone is made necessary to book a hall(Fig. 9).

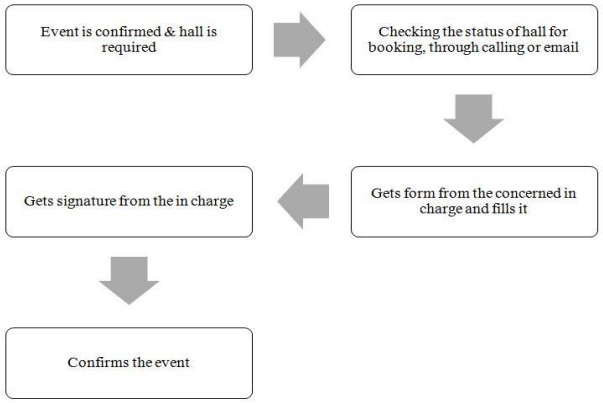


Fig. 9 Hall booking process - New

6) Approvals

The existing approval process such as leave, On-Duty, etc., involves high waiting time since the authorization is required from more than 2 persons. Therefore, a new portal is opened in a existing website, where a student/faculty can send a request through by logging in their credentials. If the request is accepted or rejected, it will be communicated in the portal itself.

V. CONCLUSION

A comprehensive literature survey shows the success of lean practices in the service sector, which also lead to proven financial returns and customer satisfaction. Only few studies were carried out in the past on implementing lean in an educational institute. Hence, in this study Lean Thinking was implemented in an educational institute. Various wastes in the existing processes were identified and solutions to eliminate the wastes are proposed. The proposed solution are tested for hypothesis using Chi-square test. The results of hypothesis showed significant change after implementation. Therefore, the proposed solutions are implemented. The reduction in inventory wastes were found to be 66.67% and a significant reduction in motion waste, waiting time and optimum utilization of resources (both paper and human resources) was observed.

REFERENCES

[1] Alsmadi, M., Almani, A, and Jerisat, R., 2012. A comparative analysis of Lean practices and performance in the UK manufacturing and service sector firms. Total Quality Management & Business Excellence, 23(4), pp.381–396

[2] Schiele,J.J and McCue, C.P. (2011), Lean thinking and its implications for public procurements: Moving forward with assessment and implementation, Journal of Public Procurement, 11(2), pp.206- 239.

[3] Barber, M., Donnelly, K. and Rivizi, S.(2013), An Avalanch isComing –HigherEducation and the Revolution Ahead, Institute of Public Policy Research Publication, London.

[4] Antony, J., Krishan, N., Cullen, D. and Kumar, M. (2012), "Lean Six Sigma for higher education institutions (HEIs): challenges, barriers, success factors, tools/techniques", International Journal of Productivity and Performance Management, Vol. 61 No. 8, pp. 940-948.

[5] Radnor, Z. and Bucci, G. (2011), Analysis of Lean Implementation in UK Business Schools and Universities, ISBN 978-0-9567461-1-5, Association of Business Schools Publication, London.

[6] Alexander , D. S., & Fadden , J. B. (May 25–26, 2017). A Value-Stream Mapping Success Story: MBA Recruiting Process Improvements. *4th INTERNATIONAL CONFERENCE ONLEAN SIX SIGMA FOR HIGHER EDUCATION*, (pp. 40-49).

[7] Robinson , M., &Yorkstone , S. (2014). Becoming a Lean University: The Case of the University of St Andrews. In *Leadership and Governance in Higher Education, Volume No. 1* (pp. 42-71). www.ig-handbook.info.

[8] Fisher, W. W., Barman , S., & Killingsworth, P. L. (2011). Value stream mapping for improving academic advising. *Int. J. Information and Operations Management Education, Vol. 4, No. 1*, 45-59.

[9] STANCA, C. (2002). Implementation of quality management systems in Romanian maritime education and training

[10] Brouwer-Hadzialic, L., &Wiegel, V. (2016). Case study: using value stream mapping in the educational process - how focusing on student actions can help depict the teaching process. *Int. J. Six Sigma and Competitive Advantage Vol. 10, No.1*, 50-61.

[11] Höfer, S., &Naeve, J. (2017). The Application of Lean Management in Higher Education. *International Journal of Contemporary Management, Volume 16, Number 4*,, 63-80.

[12] Chourasia, R., &Nema, D. (2016). Review on Implementation of 5S methodology in the Services Sector. *International Research Journal of Engineering and Technology (IRJET), Volume 03, Issue 04*, 1245-1249.

[13] Gopalakrishnan Narayanamurthy, Gurumurthy Anand, Raju

Chockalingam, (2017) "Applying lean thinking in an educational institute – an action research", International Journal of Productivity and Performance Management , Vol. 66 Issue: 5

[14] Punnakitikashem, P., Buavaraporn, N., Maluesri, P., &Leelartapin, K. (2012). Health Care Service Quality: Case Example of a Hospital with Lean Implementation. *POMS 23 rd Annual Conference.* Chicago, Illinois, U.S.A.

[15] Charles R. Gowen III Kathleen L. McFadden Sriranjita Settaluri, (2012),"Contrasting continuous quality improvement, Six Sigma, and lean management for enhanced outcomes in US hospitals", American Journal of Business, Vol. 27 Iss 2 pp. 133 – 153

[16] Jiju Antony, Netasha Krishan, Donna Cullen, Maneesh Kumar, (2012) "Lean Six Sigma for higher education institutions (HEIs): Challenges, barriers, success factors, tools/techniques", International Journal of Productivity and Performance Management, Vol. 61 Issue: 8, pp.940-948

[17] Retrieved from https://www.statisticssolutions.com/using-chi-square-statistic-in-research/