Exploration of Lean Principals in Higher Educational Institutes – Based on Degree of Implementation and Indigence

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Abstract— Increased competition and scarcity of resources in global markets has augmented the problems for manufacturing industry, which has forced organizations to adopt new tools and techniques in order to find the proactive solutions. In Past, manufacturing industry has exemplified that the key to survive in highly competitive and rapidly changing environments is to implement the more effective, proactive and long term solutions to a problem. Similar to the manufacturing organizations, higher educational institutes are facing similar challenges such as increased competitions, higher quality of service at competitive cost and variability in customer demand in terms of requested services. In fact, in terms of problem landscape, associated problem variables and goals for higher educational institutes are similar as of manufacturing industries. The only difference is the way these are interpreted and represented. Lean principles and waste used by the manufacturing organizations are used as basic building block for this research. The main objective of this paper is to illustrate the waste in higher educational institutes with respect to the three fundamental elements i.e. Students, Research and Staff. This can provide the basic framework for other process improvement implementations in higher educational institutes. Along this, the other most important aspect is the indigence to implement Lean based approaches and up to what extent as well as effectiveness of implementation in terms of invested time, resources and money. The scope of this paper is limited to interpret the waste in higher educational institutes, which can act as basic framework for other process improvements in the educational industry. This is step forward to implement Lean based structure to the higher educational institutes in order to maximize the revenue, throughput and customer satisfaction with high quality products and minimize the cost and waste, which one of the objective of any organization.

Index Terms— Continuous Process Improvement, Problem Solving, Process Waste, Lean Manufacturing, Higher Educational Institutes.

1 INTRODUCTION

Manufacturing organizations have learnt a tough lesson by going through a number of industrial revolutions, i.e. from craft production system to mass production system and then Toyota production system to Lean manufacturing. Lean manufacturing philosophy has enabled organization to deal with high level of product customization at smaller quantities. There are numerous examples of Lean tools and techniques have been applied for process improvement across the manufacturing organizations, such as automobile manufacturers, Steel manufacturing, pharmaceutical manufacturer of drugs and low cost based manufacturing industries, Electronics Manufacturing etc. [1, 2, 3 and 4]. This is not only the manufacturing industries however, which have benefited from the Lean philosophy, Lean tools and techniques have been used successfully in the service industry such as healthcare, process based industries, office environment, software development, public services, Law enforcement, banking and finance, aerospace and military etc. At the same time, Lean tools and techniques have been integrated with advanced simulation, artificial intelligence, evolutionary algorithms (EA), etc to address manufacturing problems and process improvement issues [5, 6, 7 and 8]. For instance, Lean and simulation modeling being used in the healthcare for process improvement and evaluation of existing procedures such as to eliminate the duplicate process and procedures to improve the quality of service by reducing the lead time in terms of recording the patient details, moving patients, waiting for doctors and consultants, etc [9]. Similarly, Lean philosophy has been successfully applied to the software development process for instance, by implementing Lean; eBay reduced all the unnecessary steps from the trading chain where software capabilities were developed based on daily customer needs, Digital River provided sophisticated and customized graphical user interface and database solutions in the period of weeks, Microsoft's lean based corporate wide strategy implemented across financial, human resource and purchasing departments using the data warehouses, etc [10 and 11]. In these examples, the focus remained to address the need of rapid response to complex and specific customer requirements with reduced cost and improved productivity of software development process. [12] has also applied Lean thinking to information management by focusing on the key information management activities i.e. how information is organized, visualized and represented and most importantly enabling information to flow to the end-user through the processes of exchange, sharing and collaboration. Lean implementations across different sectors have shown enormous benefits in terms of labor and productivity improvement (45-75%), cost saving (25-55%), space reduced (35-50%), inventory reduced (60-90%), rework (50-90%) and delivery improvements (60-90%), etc. [4 and 13].

On the other hand, in case of education industry, there are very few examples where Lean tools and techniques have

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been implemented in higher educational institutes (HEI). For instance, [14] has explored the Lean based tools and techniques to examine the conceptual problems of applying continuous quality improvement in higher education. Similarly, [15] has presented a case study in applying Lean sustainability concepts to HEI. In these case studies however, there is no clear inference being drawn that how the waste can be related at the operational level with the originally defined wastes in the Lean manufacturing philosophy. The main aim of this paper therefore, is to present a clear picture of waste in HEI and how this can be interpreted in Lean terminology. This paper is structured as; firstly, in section 2, the Lean philosophy being introduced briefly in context of manufacturing, which illustrates the concept of Lean, five principals and seven wastes. Further, in section 3, derives relation between Lean and HEI operation and defines waste for HEI processes w.r.to Students, Research and Staff and section 4, discusses the importance of the implementation of Lean in HEI. Finally, Section 5 presents the key highlights of the research and elaborates on the future work.

2 LEAN PHILOSOPHY

Lean manufacturing is one of the initiatives that many major businesses across the globe have been trying to adopt in order to remain competitive in an increasingly competitive global market. Lean philosophy originated in Japan from Toyota production system having the fundamental concept of a continuous flow production. Lean did not rely on the long production runs to be efficient, despite it was based on the recognition that only a small amount of the total time and effort adds value to the end customer. In fact, this was clearly against the mass production system originally developed by Henry Ford, which supports production of large volume of standardized products with minimal product changeovers [16]. The basic idea is to develop a highly efficient, customer focused and streamlined system. Researchers have regarded lean as a total business philosophy that can be applied to all aspects and types of manufacturing. The main concept of lean is in concentrating to highlight the added and non-added value process/activities, which can help in improving the efficiency of production lines by expenditure of resources for a goal and service or end product except waste. The main focus remains waste reduction through a systematic approach of continuous process improvement at the pull of customer in pursuit of perfection. The ultimate benefits of reducing the waste can be seen as shorten lead times, improved quality, competitive advantage, reduced cost, etc. [5, 17, 18 and 19]. The idea is to develop a system that can flexibly respond to the customer demand and efficient at the same time.

2.1 Five Principals

Lean is based on the five principals, which are the basic building blocks for the Lean philosophy implementation. Table 1, illustrates the fundamental concept of Lean based on five key principles [9, 12, 16, 19 and 20]. Implementing five Lean principles ensures that overall organizational strategy is followed by continuous review of your processes to ensure that they are constantly and consistently delivering value to your customer. This allows organizations to maintain its' high level of service whilst being able to grow and flex with a changing environment and it does this through implementing sustainable change.

TABLE 1
LEAN FIVE PRINCIPALS

Lean Principal	*Illustration*
Identify Value	The first and foremost important step of lean thinking is the identification of customer and definition of value from customer perspective (for instance, what customer wants at what time and price) and what resources and activities are absolutely necessary to create that value. Once value is identified, everything else is waste and can be targeted for removal.
Map the Value Stream	The Value Stream is the entire set of activities or actions across all parts of the organization involved in jointly delivering the product or service. This represents the end-to-end process that delivers the value to the customer.
Create Flow	Create flow based on the value creating activities or actions as identified in the previous step. This will ensures that your product or service "flows" to the customer without any interruption, detour or waiting
Respond to Customer Pull	Understand the customer demand and create process to respond accordingly i.e. Sell one make one.
Pursue Perfection	There is no end to the process of reducing lead time, buffer space, cost, mistakes etc. As process improvement begun more and more layers of waste become visible and process continues towards theoretical point of perfection.

2.2 Lean Wastes

From the basics definition of Lean, an activity is not waste if and only if it transforms the product into something the customer wants. Waste is therefore, anything that doesn't add value to product from customer point of view but adds towards the time and cost. It is essential therefore, to highlight the value added and non-value added activities from process such that non value added activities can be targeted for removal in order to achieve high quality, customer satisfaction and profit [18 and 19]. Some of the non-value added activities however, are still important to make end product according to customer specifications. For example, from customer point of view set-up time is waste but set-up time is essential to add value to final product. However, setup time can be reduced under lean continuous improvement exercise. Table 2, briefly illustrates over the waste/non-value added activities in Lean context [2, 9, 10, 12, 18, 21, and 22].

There are different Lean tools and techniques being used to

reduce waste, these are referred as Lean building blocks; some of which for instance, are pull system, Kanban, work cells, total productive maintenance, total quality management, quick changeover, point-of-use-storage, batch size reduction, visual controls, 5S, standard operations, etc. Explaining these tools in detail is out of scope of this paper however, section 4 introduces the usage of some of the tools from the improvement point of view in higher educational institutes (HEI).

TABLE 2
WASTE IN LEAN

Waste	*Illustration*
Over-production	Producing anything more than customer demand or specifications, this contributes towards waste of time, resources and material. According to Lean principals even providing extra features as overproduction. Overproduction can be reduced by working specific to the customer demand.
Waiting	Queuing or downstream process is waiting for upstream activities to finish. The waiting can be for material, information, equipment, tools, resources etc. Waiting can be reduced by providing things Just-In-Time (JIT).
Transportation	Material should be delivered straight to its point of use to minimize the unnecessary movement of material either from warehouse to factory or between different workstations. Transportation adds towards time and cost and degrades the quality of final product. Transportation can be minimized by improving shop floor layout or delivering the material to point-of-use-storage (POUS).
Over Processing	Known as non-value added processing as well. Over processing doesn't add value to the customer. Most common examples of over processing are rework, testing, sampling, inspection. Over processing can be reduced using Lean tools such as value stream mapping.
Excess Inventory	Represents the frozen asset or value that is beyond the need to fulfill current customer needs, which can be raw material, WIP and finished products (over production). This requires additional handling and storage space, which adds on cost, time and decreases quality.
Defects	Errors during the production process or service delivery required i.e. finished products doesn't pass the quality test. This represents waste in terms of material consumed, time (initial and rework), cost and resources. Also, if defected product is sold to customer this can lead to customer dissatisfaction.
Excess Motion	The excessive movement of the people who operate the manufacturing facility is wasteful. Whilst they are in motion they cannot support the processing of the product Excessive movement of data, decisions and information. Inefficient layout, defects, reprocessing, overproduction and non-standard working methods are the causes of excess motion. Standard and well documented operations are essential to reduce excess motion.

3 LEAN AND HEI

In modern educational environment competition is fierce. In fact, HEIs are in an edge to edge competition with both national and international institutes in terms of quality of service provided to students against the fees paid. The overall quality of service here represents the educational facilities in terms of educational quality, learning environment, facilities (lecturing, labs, library etc.) and the services provided to support these facilities in terms of student life and experience. Along this in recent years, addition to the basic educational facilities, students search for other marks of quality: safe and up-to-date residence halls, state-of-the-art facilities, and the latest offerings in technology. In order to provide these facilities to students fees have been increased astonishingly over the years. At the same time, increased fees have increased the student expectations and in turn this has build up pressure on HEI to improve their services; which has lead to the idea of doing more with less. To find success therefore, HEI must demonstrate that they can offer what others cannot. In the competitive context, one of the most efficient ways forward is to use the resources optimally or efficiently by reducing waste from the different activities in order to reduce the operational cost and to improve the quality of service [4, 23 and 24].

One of the aspects of this research is to understand the waste is at three main levels or fundamental blocks of any HEI, i.e. Student, Research and Staff. All three are complementary measure for the performance of any HEI. For instance, students and research are the two main sources for the income to the university, which implies that to maximize the income from the research and students, waste has to be removed from all the activities related to these processes, which can be due to the direct and indirect relation between the internal processes. For instance, both academic and administrative processes have the impact on the student and research in terms of added cost and quality of service, waiting, extended lead times, etc. On the other hand, academic staff is one which is representing university for its academic excellence, in fact attracts more students and research income and support staff fulfills all the supportive needs. Waste therefore, needs to be targeted for removal from the perspective of academic and support staff to make operations more efficient and cost effective.

Although universities have developed their process improvement tools and techniques according to the specific problem they want to tackle. However, studies have shown that despite providing the outstanding performance in academic field there is still room for improvement in the administrative processes as the processes. According to [23 and 24],

based on a number of case studies, there is significant impact when Lean philosophy had significant effect in terms of:

1. Changing the practices which were used for years and are not efficient anymore.
2. Bringing awareness among the employees to bring the change.

This has shown positive outcomes in terms of staff and student experience. However, there is a still lot of opportunity of improvement due to the limited understanding of the key principals as very little improvements were shown in terms of cost reduction. There is a need for more focus on developing the basic building blocks of Lean and better understanding of processes and value from the perspective of HEI customers.

3.1 Waste in HEI

From the basic definition of the first Lean principal (Table 1), the first step is to understand what value is and what activities and resources are absolutely necessary to create that value and everything else is waste. The main focus is to remove the steps from processes that are not necessary and do not add any value for the student, research or staff.

In order to understand the concept of implementation let's consider the basic process; such as lecturing, new student enrolment, research biding, etc. Each of the process is made up of discrete steps that consist of a defined beginning step, a defined end step and there are number of steps to go from the beginning to the end. These intermediate steps produce the required product or service for the end customer i.e. student, staff or research in this case. It is therefore, essential to understand the intermediate steps that what value these steps add from the end customer's perspective. Once these value added steps are identified then waste can be eliminated. In order to understand Lean manufacturing waste in HEI Table-A (Appendix A), exemplifies the waste in the HEI processes w.r.to Student, Research and Staff.

4 Degree of Implementation and Indegience

In The second main issue this paper addresses, is the importance of implementation of Lean in HEI and what processes can be improved in the tradeoffs of cost of implementation of Lean and improvements made from Lean implementation in terms of invested money and time. In fact, some of the previous studies have shown that to be competitive in the modern HEI environment, services needs to be expended much beyond the basics of education i.e. delivering lectures, marking, generating results, etc. There are pressure to expand services which can benefit both students and staff i.e. staff to achieve their long and short term goals, improve student performance, achieve research excellence, maintain the number of students and best quality students, meeting workplace requirements, etc. at minimal cost due to pressure of decreased funding from government [4, 15, 23 and 24].

One of the examples of waste from the staff perspective is finding a student file; discrete steps for this process can be logging in to the system, search for the student file, retrieve file and email or print the file. Waste can be identified in the process as:

1. If the data is not stored in appropriate directory, using the standard naming conventions then going through the file system to find the student information can be tedious.
2. Even this can be impossible to find student information if this needs to be retrieved by a person who hasn't stored the student information

On the other hand, this process is simple if a standard procedure for student data storing and standard naming conventions being used, which can remove all these non value added activities going through the different directories in order to retrieve the information. Even going step further, implementing a file access interface and having the different levels of access rights for the stored information across the staff hierarchy can remove the step of requesting the information from different sources. This can reduce the waste of excessive motion. Some of the basic Lean tools without huge investment of time and money can be implemented, such as 5S, Lean creative problem solving, root cause analysis, process mapping, spaghetti diagrams, value stream mapping, visual management techniques, team meetings, brain storming, etc. Similarly, there are numerous other processes, which can be improved using similar tools or possibly more complex tools, some of these processes are; admissions, timetabling, attendance monitoring, teaching, assessment, fees collection, library processes, research life cycle, etc.

Certainly there are some recommendations given by previous studies based on the simple Lean tools and techniques [4 and 23], which stresses on the understanding of end-to-end processes i.e. student, research and staff life cycles and adding value according to their requirements. Evidently some the benefits of Lean implementation in HEI can be given as:

1. If the data is not stored in appropriate directory, using the standard naming conventions then going through the file system to find the student information can be tediousLean can deliver benefits to support the quality and timing of information, which can lead to better processes and satisfied customers.
2. Using standard operation procedures can lead to process improvement by:
    a. Avoiding data collection, processing and analysis errors.
    b. Avoiding collection of same data several times.
    c. Standardizing the visualization and flow of information to minimize the errors or misinterpretation.
    d. Standardizing the policies and regulations across the departments in order to minimise the confusion over the process flow.
    e. Minimising the mishandling of information or decisions by excessive moment of information.
3. Using problem solving techniques that can work across the departments and teams and can be learnt easily. Developing the active problem solving structures can lead to the effective process improvement activities.
4. Improving the visual management across the organization by having;
    a. The consistent layout across.

b. Standard format to display information, announcements, performance, student results, timetable, etc.

5. Development of better communication and information delivery methods by sharing the best practices.
6. Workplace and information flow improvement using the 5S' to reduce the errors and mishandling of the information.
7. Having tasks being scheduled in correct order and effective resource allocation can improve the quality of service across student, research and staff.
8. Minimising the data and physical inventories to reduce cost and improve quality of service. Physical inventories are stationary and the equipment ordered in excess. Data inventory represents the data being saved at several places or same data being collected several times, which can lead to errors, mismatching or mishandling of data.
9. Improving process efficiency, flexibility and improved performance.
10. Reduce backlogs, cost, error and wasted time, which all contributes towards released capacity.
11. Increased productivity, problem solving and job satisfaction among staff.

Table 3, illustrates the possible ways of waste elimination by implementing some of the simplest procedures of the Lean process improvement, such as 5S, standard operation procedures, multi-skilled workers, etc, which are generic steps can be applied across the different processes.

TABLE 3
POSSIBLE WAYS TO ELIMINATE WASTE

Waste Type	*Possible ways to eliminate this waste*
Over production	• Establish a workflow sequence to satisfy the downstream customer • Establish workplace norms and standards for each process • Develop signaling procedures to prevent early processing
Waiting	• Review and standardize required signatures to eliminate unnecessary ones • Cross train employees to allow work flow to continue while somebody is out • Balance the workload throughout the day to ensure optimal use of all people • Make sure the equipment, information and supplies are available
Transportation	• Make the distance over which something is moved as short as possible • Eliminate any temporary storage or stocking locations
Over-processing	• Review value-added steps in each process and eliminate steps where ever possible • Review the associated process requirements and eliminate non-value added process steps where ever possible
Excess Inventory	• Produce only enough to satisfy work requirements of the customer • Standardize work locations and the number of units per location • Ensure that work arrives at the downstream process when required and does not sit there
Defects	• Establish standardized work procedures and office forms • Create and post job aids
Excess Motion	• Standardize folders, drawers, and cabinets throughout the office area • Arrange files in a way that they are easily referenced • Arrange work areas of office equipment in central locations • Purchase additional office equipment

All of this however, comes with a cost, most importantly requires the commitment from the staff especially from the management to implement the changes. According to [23 and 24] senior management needs to be actively involved and needs to take the ownership of lean programs. In fact, the idea behind the Lean implementation is just not to implement changes but sustaining those changes effectively in order to develop a continuous process improvement methodology.

5 DISCUSSION AND CONCLUSSION

It is evident from previous studies that Lean programmes have significant impact when implemented in the HEI. The most important aspect is to create an understanding of the need to change, revising process and practices, which are not touched for years and enabling staff to challenges these work practices [4 and 23]. There is not much literature present where the Lean implementations have been discussed and relation to the original seven wastes being created. While, the particulars of how Toyota or other manufacturing organizations have applied Lean solutions in their circumstances may not all fit in the HEI, the wastes needs to be identified w.r.to the problems in HEI. Current research has investigated the implementation of Lean in the HEI at different levels and it is clear that not only the manufacturing organizations but HEI can also reap benefits from Lean tools and techniques at operational, administrative and strategic level. Also, the other main difference is the problems and their complexity, associated variables and the way variables are represented. One of the main objectives of this paper is identify waste w.r.to the main focuses in the HEI i.e. Student, Research and Staff and relate it to the original Lean waste so that a process improvement framework can be established. There are no previous studies which has identified waste w.r.to basic elements of HEI i.e. student, staff and research. This can provide a starting point for process improvement activities by providing the basic information about the possible waste in HEI. However, as a part of continuous process improvement framework, going through the basic process will reveal hidden layers of waste, which may require more sophisticated tools and techniques. Along this, to reap the true benefits of Lean philosophy individual processes needs to be investigated at opera-

tional level.

REFERENCES

[1] Abdulmaleka, F. A. and Rajgopal, J. "Analyzing the Benefits of Lean Manufacturing and Value Stream Mapping via simulation: A process sector case study", International Journal of Production Economics, Vol. 107, pp. 223 – 236, 2007.

[2] Melton, T. "The benefits of Lean Manufacturing, What lean Thinking has to Offer the Process Industries", Journal of Chemical Engineering Research and Design, Vol. 83, Issue 6, pp. 662 – 673, 2005.

[3] Doolen, T. L. and Hacker, M. E. "A Review of Lean Assessment in Organizations: An Exploratory Study of Lean Practices by Electronics Manufacturers", Journal of Manufacturing Systems¸ Vol. 24, No. 1, pp. 55 – 68, 2005.

[4] Ziskovsky, B. and Ziskovsky, J. "Doing More with Less – Going Lean in Education", A White Paper on Process Improvement in Education, Lean Education Enterprises Inc. Shoreview, Minnesota, pp. 1 – 19, 2007.

[5] Khalil, R., Kang P. and Stockton D. "Integration of Discrete Event Simulation with an Automated Problem Identification", Proceedings of International Multi-Conference of Engineers and Computer Scientists (IMECS 2010), Vol. 2, March 17 – 19, 2010, Hong Kong.

[6] Kang, P. S., Khalil, R. and Stockton, D. "Integration of Design of Experiments with Discrete event Simulation for Problem Identification", Proceedings of the International Junior Scientist Conference, April, 2010, Vienna, Austria, pp. 69 – 70.

[7] Kang, P. S., Khalil, R. and Stockton, J. "A Multi-Objective Optimization Approach Using Genetic Algorithms to Reduce the Level of Variability from Flow Manufacturing", Proceedings of 2012 IEEE International Conference on Engineering Technology and Economic Management, Vol. 1, Zhengzhou, China, pp. 115 – 119, May 2012.

[8] Rahani, A. R. and Al-Ashraf, M. "Production Flow Analysis through Value Stream Mapping: A Lean Manufacturing Process Case Study", International Symposium on Robotics and Intelligent Sensors – IRIS 2012, Vol. 41, pp. 1727 – 1734.

[9] Robinson, S., Radnor, Z. J., Burgess, N. and Worthington, C. "SimLean: Utilising Simulation in the Implementation of Lean in Healthcare", European Journal of Operational Research, Vol. 209, Issue 1, pp. 188 – 197, 2012.

[10] Poppendieck, M. "Principals of Lean Thinking", Technical Report, Poppendieck LLC, Minnesota, 2001. USA.

[11] Al-Kaabi, M. "Improving Project Management Planning and Control in Service Operations Environment", PhD Thesis, De Montfort University, Leicester, UK, 2011.

[12] Hicks, B. J. "Lean Information Management: Understanding and Eliminating Waste", International Journal of Information Management, Vol. 27, Issue 4, pp. 233 – 249, 2007.

[13] De Souza, L. B. "Trends and Approached in Lean Healthcare", Journal of Leadership in Health Services, Vol. 22, Issue 2, pp. 121 – 139, 2009.

[14] Roffe, I. M. "Conceptual Problems of Continuous Quality Improvement and Innovation in Higher Education", Journal of Quality Assurance in Education¸ Vol. 6, No. 2, pp. 74 – 82, 1998.

[15] Comm, C. L. "A Case Study in Applying Lean Sustainability Concepts to Universities", International Journal of Sustainability in Higher Education, Vol. 6, No. 2, pp. 134 – 146, 2005.

[16] Womack, J.P., Jones, D.T. and Roos, D. "The Machine that Changed the World: The Story of Lean Production (HarperCollins Publishers, New York, USA), 1990.

[17] McKellen, C. "Total productive maintenance", International Journal of Quality & Reliability Management, Vol. 149, No. 4, pp. 18 – 38, 2005.

[18] Kilpatrick, J. "Reports on Lean Principal", Lean Manufacturing Extension Partnership, Utah, USA, pp. 1 – 5, 2003.

[19] Liker, J. K. and Lamb, T. "Develop and Implement Model for U.S. Commercial and Naval Ship Construction", Lean Manufacturing Principals Guide, The University of Michigan, USA, 2000.

[20] Raman, S. "Lean Software Development: Is It Feasible?", The Proceedings of 17th International Digital Avionics System Conference, 31st Oct. – 07th Nov., Seattle, USA, pp. C13/1 – C13/18, 1998.

[21] Freire, J. and Alarco, L. "Achieving Lean Design Process: Improvement Methodology", Journal of Construction Engineering & Management, Vol. 128, Issue 3, pp. 248 – 256, 2002.

[22] Theuer, H., Gronau, N. and Lass, S. "The Impact of Autonomy on Lean Manufacturing Systems", Advances in Sustainable and Competitive Manufacturing SystemsLecture Notes in Mechanical Engineering, Part V, pp. 1413 – 1423, 2013.

[23] Randor, Z. J. and Bucci, G. "Executive Summary – Analysis of Lean Implementation in UK Business Schools and Universities", AtoZ Business Consultancy, pp. 1 – 74, 2011.

[24] Rainfsnider, R. and Kurt, D. "Lean Six Sigma in Higher Education: Applying Proven Methodologies to Improve Quality, Remove Waste and Quantify Opportunities in Colleges and Universities", White Paper – Global Services in Consulting, pp. 1 – 10, 2004.

APPENDIX – A

TABLE A
WASTE IN HEI

Waste Type	*Waste in HEI*	*Symptoms from the perspective of;*		
		Student	*Research*	*Staff*
Over-production	• Substitute or Incorrect Services • Services developed for no specific customer • Development of alternative facilities which may not be in use at all.	• Course or Module Material out of the Course or Module Template • Outdated teaching material	• Out of scope or wrong research outputs. • Generation of unnecessary information. • Use of obsolete technology. • Inadequate project tasks planning and resource allocation.	• Generation of unnecessary information about students or staff. • Generating data or information not required for immediate use or at all.
Waiting	• Miscommunication, unclear procedures or confusion, this causes waiting for seeking clarification over using a product or service • Locating a product or service • Particular person cannot leave the site (lab/lecture/room) until task is finished. • System downtime • System response time • Approvals from others, decision hierarchy • Information from customers	• Waiting for a service for instance, library, fees payment, forms submissions, etc. • Waiting due to incomplete or inconsistent or wrong information. • Inefficient scheduling of resources among students; classic example is on a given day there are only two teaching slots one in morning and one in evening. • Waiting for resource to be freed i.e. lecture/lab is running over the assigned time slot in the current classroom and next set of students waiting for room to be freed. • Students waiting for equipment which needs to be moved from different location.	• Delays in the information release (confidentiality or internal procedures to follow) • Delays in the information issuing process of an equipment or tool. Due to complex or lengthy issuing process. • Miscommunication or inadequate communication between project team. • Inadequate project tasks planning and resource allocation. • Waiting for equipment or tool, needs to be used among collaborators.	• Incompetent staff • Inadequate planning of tasks for instance, admin staff being waiting for academic staff to submit marks to add to system in order to generate the results. There should be no waiting if tasks are planned optimally. • Waiting for resource to be freed i.e. lecture/lab is running over the assigned time slot in the current classroom and lecturer is waiting for room to be freed. • Academic staff waiting for equipment which needs to be moved from different location.
Transportation	• Moving products or services to the different location. Motion is not adding any value. • Not having the basic facilities in every room. • Commonly required material is stored away from the point of use. • Required product or service is not present at point of use. • Excessive e-mail attachments • Multiple hand-offs	• No centralized location for the virtual storage for students. • Lack of facilities which allow students to access and submit assignments or course works seamlessly. For instance, online assignment or project submission system.	• Moving experimental equipment or material between collaborators or labs. • Inefficient and non standard procedures for the data collection and communication, which allows data to go through number of unnecessary steps before used by process or	• Moving the equipments; for instance, moving the audio visual equipments. • Material is not present at point of use; for instance printer papers are stored at a central location instead of labs. • Staff has to get daily necessities from a different site.

	• Multiple approvals		person.	
Over-processing	• Inability to deliver services at first instance, for instance more cautious approach if used; such as testing or rechecking may be added to make sure there are no mistakes which are non value added steps • Duplication of information for instance, same data collection and same entering data to system several times • Re-entering data • Extra copies • Unnecessary or excessive reports • Month-end closing activities • Multiple approvals	• Incomplete information about the procedures i.e. for instance incomplete or ambiguous instructions to about coursework. • Extra session for students to deliver already delivered sessions (not the revision sessions but delivering whole lab or lecture session again). • Overlapping module templates, where students are studying the same material more than once.	• Incomplete information about the procedures to follow, which can lead to adding extra procedures such as rechecking and possibly redoing the work. • Duplication of effort due to; lack of communication in team or inefficient documentation. • Not reusing the developed technology in the recent projects due to lack of efficient documentation.	• Admission process for new students; details being checked at several stages. • Result creation process; marks being checked and entered to system at a number of stages. • Unnecessary forms or duplication of information several times.
Excess Inventory	• Storage of raw material which is not in immediate use or is in excess • Re-entering Data again and again on forms • Repeated details on several forms • Copying same information across the different departments • Purchasing items before they are needed • Batch processing transactions • Outdated or unnecessary literature.	• Waiting lists; students waiting to be dealt with same or similar queries across different departments. • Students waiting for the results or coursework feedback. • Waiting for managerial level decision.	• Pending decisions. • Information about event, process or research problem captured on paper forms then need to enter into central database system. • Same information collected again and again. • Tools or equipments bought for research but never being used.	• Information about event, process, students being captured on paper forms then need to enter into central database system. • Same information collected again and again. • Excess material in store rooms not being used, such as buying excessive stationary.
Defects	• Errors in the service transactions • Incomplete documents • Data entry errors • General misconducts • Design errors	• Incorrect information, which requires redelivery. • Course or module material out of course template. • Repeating the exam or coursework due to the incorrect information.	• Incorrect or incomplete research outputs or documents produced then time or effort spent to correct it. • Initial data collection or modeling errors.	• Incorrect information or protocols leads to redo the work. • Incorrect information processed or entered to system; for instance wrong student or results being entered.
Excess Motion	• Excessive movement of data, information and decisions • Lack of required service and information • Walking to and from the copier • Central filing • Walking to and from the fax machine • Walking to and from other offices	• Students unnecessary being moved between different classrooms. • Unnecessary student moment looking for information for instance, module or results feedback or submission of course work.	• Collaborative meetings to take key decisions and monitor project progress. • Information, equipment or decision from a centralized location.	• Moving the documents data from place to place. • Staff movement to take the key decisions.