

POLITECNICO DI MILANO

School of Industrial and Information Engineering

Mater of science in Management Engineering



POLITECNICO
MILANO 1863

ADVANCEMENT OF THE OPERATIONS MANAGEMENT COURSE HANDLED BY
LEAN EXCELLENCE CENTER AT POLITECNICO DI MILANO

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Academic Year: 2021/2022

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ABSTRACT

The world we live in is continuously evolving, every other minute an Innovation or a Discovery is made. It is essential for us keep up with this changing environment and be updated with what is happening around. There has been many researches made to increase the quality of life, be it in manufacturing industries or in any service sectors. That does not mean that sticking to the basics is unnecessary, in addition to having strong roots one must be in line with any kind of information that has been new to have a sustainable and better living.

Lean Excellence Centre at Politecnico di Milano is a part of Industrial and Information Engineering, which has various courses under it such as Operations Management, Industrial Management Tool box, Industrial Management Lab, Industry4.0 etc. This centre thrives in giving out information that is very useful for various managerial activities that happen in day to day life not just only in business sectors. Many researches are in progress and are also completed that gives out the useful knowledge where a student can make use of it in the best way possible and get ready to face the world.

This report aims to Improve the course content or aims to provide new methodology for teaching purpose. The main focus is especially on Operations Management course. Top tier universities present in various parts of the world are selected and short listed, where they teach the similar courses. After selection the data regarding the course content and the teaching methodologies, case studies used are studied. With the help of Benchmarking Analysis we benchmark the course structure, the methodology, student experience during and after the course, assessment activities etc., After benchmarking and finding out the best practices a suggestion report to apply it to course at Polimi is to be given where you apply the same or improve the findings and then apply them in a best possible way to the benefit of students to make them ready to face the real life challenges.

ABSTRACT (ITALIANO)

Il mondo in cui viviamo è in continua evoluzione, ogni minuto si realizza un'Innovazione o una Scoperta. È essenziale per noi stare al passo con questo ambiente in evoluzione ed essere aggiornati su ciò che sta accadendo intorno. Sono state fatte molte ricerche per aumentare la qualità della vita, sia nelle industrie manifatturiere che in qualsiasi settore dei servizi. Ciò non significa che non sia necessario attenersi alle basi, oltre ad avere radici forti bisogna essere in linea con qualsiasi tipo di informazione nuova per avere una vita migliore e sostenibile.

Il Lean Excellence Center del Politecnico di Milano fa parte dell'Ingegneria Industriale e dell'Informazione, che ha vari corsi al suo interno come Operations Management, Industrial Management Tool box, Industrial Management Lab, Industry4.0 ecc. Questo centro prospera nel fornire informazioni che sono molto utile per varie attività manageriali che accadono nella vita quotidiana non solo nei settori aziendali. Molte ricerche sono in corso e sono anche completate che danno le conoscenze utili a cui uno studente può utilizzarle nel miglior modo possibile e prepararsi ad affrontare il mondo.

Questo rapporto ha lo scopo di improvvisare il contenuto del corso o mira a fornire una nuova metodologia per scopi didattici. Il focus principale è in particolare sul corso di Operations Management. Vengono selezionate e preselezionate le università di primo livello presenti in varie parti del mondo, dove tengono i corsi simili. Dopo aver selezionato i dati relativi ai contenuti del corso e alle metodologie didattiche, vengono studiati i casi di studio utilizzati. Con l'aiuto dell'analisi di benchmarking confrontiamo la struttura del corso, la metodologia, l'esperienza dello studente durante e dopo il corso, le attività di valutazione ecc. Dopo il benchmarking e la scoperta delle migliori pratiche viene fornito un rapporto di suggerimento per applicarlo al corso al Polimi dove applichi lo stesso o migliori i risultati e poi li applichi nel miglior modo possibile a beneficio degli studenti per prepararli ad affrontare le sfide della vita reale.

CHAPTER 1: INTRODUCTION

1.1. Operations Management

All businesses produce something, be it tangible or intangible. Traditionally, when we think about production, we get the remembrance of firms that manufacture physical goods in factories and on production lines. However, the experience of most modern, developed economies is that the manufacturing element is actually a smaller part of the economy than the provision of services. There are exceptions; Germany, for example, is still a significant manufacturing and exporting economy.

Production is deals with converting inputs such as raw materials into finished products which will meet the needs and wants of the market and the customers within them. The process of production will be adding value allowing firms to impose a higher price for the finished product than the costs incurred while producing the finished goods.

Production describes a relatively static process, but the term operations management refers to the management of the production process and describes a wide range of activities; it is by far also better suited to firms that produce services rather than physical goods.

1.2. What is Operations Management?

Operations Management is mainly concerned with the design of products and its services and the management of its production processes and supply chains involved. It describes the process of acquisition, development, and utilisation of the resources that firms required to produce and deliver of the goods and services that their customers want. It embraces a lot of management procedures and techniques to establish the science of operations management. There are different views about the definition of operations management. some define operations management as the part of an organization that is entrusted with the sole responsibility of coordinating the operation functions and processes that seeks to successfully transform raw- materials or resources into finished goods and services. The raw materials are in the form of transforming and transformed inputs. The transformed input resources are acted upon and converted in the transformation process, such as information, materials. While transforming input resources are being acted by the transformed input resources, such as buildings, plant, equipment and the people who operate it & manage this process to produce finished goods and services for the customer.

Operations management is the branch of business concerned with managing business practices to maximize efficiency within an organization. Organizing, planning, and overseeing an organization's processes to balance costs and revenues is essential in achieving the highest possible operating profit. The operations manager is responsible for ensuring that the organization is able to efficiently convert inputs such as materials, labour, and technology into outputs.

Operations management encompasses both strategic and tactical activities. example, senior management needs to make strategic decisions about the size and location of factories, the level of research and development, and planning an appropriate supply chain. Managers and supervisors in middle management positions will be more concerned with tactical issues, such as designing factories, laying out layouts, and selecting and replacing equipment. At an operational level, decisions will focus on how to produce the products that our company sells and how to keep our facilities running smoothly.

Operations management is concerned with activities within all three sectors of the economy:

- Primary sector, e.g. extracting raw materials and the harvesting of crops
- Secondary sector, e.g. manufacturing, construction and processing
- Tertiary sector, e.g. service provision.

The critical function of operations management is responsible for the management of inventory through the supply chain. To be an effective operations manager, you need to be able to understand the processes that are essential to what a company does and get them to work together smoothly. A good understanding of logistics is necessary for coordinating business processes in an efficient way.

However, there are so many challenges that oppose the successful implementation of operations management in an organisation. Though operations management in the construction industry is somewhat challenging because the construction industry is a combination or conglomerate of dynamic and ever complex networks of units operating as individual or virtual enterprises. There are various types of operations or construction such as, residential housing, commercial housing, industrial, heavy, and some of the various services are financial planning consultants, architectural and engineering firms, design/construction firms, professional construction managers, operation and maintenance managers, facilities management etc.

1.3. Historic Operations Management vs. Modern Operations Management

In the history of business and manufacturing operations, division of labour and technological advancements have benefited company productivity. Systematically measuring performance and calculating with formulas was a somewhat unexplored science before Frederick Taylor's early work in the field.

In 1911, Taylor published his principles of scientific operations management, characterized by four specific elements: developing a true science of management, scientific selection of an effective and efficient worker, education and development of workers, and intimate cooperation between management and staff

Modern operations management revolves around four theories: business process redesign (BPR), reconfigurable manufacturing systems, Six Sigma, and lean manufacturing. BPR is focused on analysing and designing workflow and business processes within a company. The goal of BPR is to help companies dramatically restructure the organization by designing the business process from the ground up. Reconfigurable manufacturing systems are designed to incorporate accelerated change in structure, hardware, and software components. This allows systems to adjust rapidly to the capacity to which they can continue production and how efficiently they function in response to market or intrinsic system changes.

Six Sigma is an approach that focuses on quality. The word "six" references the control limits, which are placed at six standard deviations from the normal distribution mean. Tools used within the Six Sigma process include trending charts, potential defect calculations, and other ratios. Lean manufacturing is a systematic elimination of waste within the manufacturing process. This theory sees resource use for any reason other than value creation for customers as wasteful and seeks to eliminate wasteful resource expenditures as much as possible.

1.4. Benchmarking

Benchmarking is a systematic process of comparing the activities and work processes of an organisation, functions and its departments with those of outstanding organisations, functions or departments, normally in the same industry, with the objectives of improving performance.

Benchmarking was first developed by the Xerox Corporation in the 1970s when Xerox realised it was losing profit and market share to its Japanese competitors, who

were able to sell photocopiers for the same price that it cost Xerox to make them. The development of benchmarking is described by the Xerox executive Robert C Camp, universally regarded as the founding father of the benchmark process, in his 1989 book: The search for industry best practices that lead to superior performance.

There are various types of benchmarking:

- Internal benchmarking - a comparison of one function with another within the same industry.
- Functional benchmarking - a comparison of one function with another, regardless of the industry.
- Competitive benchmarking - gathering information about direct competitors
- Strategic benchmarking - the objective is organisational changes through strategic action.

Benchmarking (sometimes called best practice benchmarking - BPB) is used to measure the gap between the firm's performance and the performance of other organisations in the same, or similar, industry. The firm selects a product of high quality or efficient process, possibly that of a competitor, and uses it as a standard for improvement in their own products and processes.

1.4.1. Stages of Benchmarking

Benchmarking effectively means finding out what, in the eyes of the customer, makes the difference between an ordinary product and an excellent product and then establishing procedures to implement these standards. The process requires several stages:

1. Establishing what should be benchmarked, by talking to customers about significant factors in their purchase decisions, and identifying specific areas where the firm would gain from improvement.
2. Deciding who the firm should benchmark against, by identifying those firms that have the best reputations and quality in the industry.
3. Obtaining the information using a variety of primary and secondary research methods and sources.
4. Analysing the information, particularly using quantitative methods that can be used for comparison with industry standards.

5. Establishing how the information should be used to improve the product or business practices. This will involve the firm in the setting of standards for improvement and communicating these to relevant employee groups. Senior managers must be responsible to drive these improvements forward, by providing the necessary resources and training opportunities.

It is possible to benchmark different aspects of the production process against competitors who excel in each of these areas. A car manufacturer, for instance, may benchmark the performance of its engines against one competitor, which is regarded as the market leader, and the quality of its paint finish against another, and so on.

1.4.2. Advantages of benchmarking

- By identifying the customer's key concerns, companies can make the most effective use of their resources by focusing on specific elements of their business.
- Reduce complaints, improve customer satisfaction and company reputation.
- As part of a continuous improvement process, benchmarking can reduce waste and rework of poor products.
- Reviewing best practices increases awareness of key industry innovations and alternative solutions.
- Involving employees in the benchmarking process can improve motivation and productivity.
- Increased sales and profits.

A benchmarking process is effective only if a company can obtain the necessary information about its competitors. It is highly unlikely that this information will be provided voluntarily, and the cost of obtaining the information by other means can be substantial. Even if there is information, that information alone may not be enough to replicate the process. Copying what others are doing may not give you a competitive advantage.

Benchmarking is an important process in the automotive industry. Automakers have to compete for sales because supply capacity is outstripping demand. design, function, technology, manufacturing method, design efficiency,

CHAPTER 2: OPERATIONS MANAGEMENT AT POLIMI

The Course of Operations Management at POLIMI is head by Prof. Alberto Portioli Staudacher with a team of 4 additional assistant professors. The course deals majorly with Operational Strategies, Lean Management, Service Management, Queue Theory, Yield Management and System Physics. The course delivery is done in 20 lectures with each of 180 min run time. With a special case study dedicated to that particular topic of discussion and uses various techniques which are discussed below. With an ample amount of time in the lectures to solve the exercises related to the topics gives a better understanding to use the principles in the real time application.

The course has been introduced by giving out the definitions for the Operations Management and gives out the input, transaction and output systems. Explaining the hierarchy structure of personals in an organisation. Noticing the growth of OM from only core production to the Services, Finance, HR, Marketing etc. The course has been aimed to convey the following points

- Operations are central to the company's business and mankind's sustainability.
- The skills in the Operations area are critical and strongly impact the competitive advantage. Both in industrial companies and in the service ones.
- Services are a special world, and are rapidly growing. Service Operations which is new companies are struggling to find service-specific skills.
- There is a strong innovation taking place in the management of companies and organizations i.e., Lean Management
- The fourth industrial revolution, Industry4.0.

2.1. Operations Strategies

A company in order to survive over time, needs a strategy that differentiate itself from the other competitors. There are three strategic levels as in Corporate level is the primary which allocates the resources between different markets and products. Business unit has the answer to find out which is the business they function, finally a Functional level that supports the companies in satisfying market needs. Traditional approach of the companies to give out the strategies without any interrelationships with the other department is said and with the help of an example the approach has been proven wrong and the disadvantages have been identified.

Functional strategies cannot be independent one from another, nor they can be the sequential outcome of the Business strategy; rather necessity to communicate and interact to define the strategy at Business Unit and Corporate level. Hence we use and Integrated and Bi-direction way to find out the best fitting strategy. The strategy must

be Dynamic, Deliberate and Emerging which can be developed by combining all the output from Top-down, Bottom-Up, Operations resources and Market Requirements. The Voice of the customer is given importance to improve or define a strategy. The three strategic Levers are introduced and the procedure to quantify them is explained.

Launching a case study of HQ the various model of Operations strategies have been taught. Performances are classified as Order Winners and Qualifiers. Various curves such as Break-Even curve, Lifecycle S and Four V analysis that are efficient for finding out the company's opportunities in expansion and finding better improvements for the strategy.

Strategic Capacity Management is the process of working out what resources you need to meet demand, whether that be next year or just trying to work out who is available next week. Capacity planning is the thought process behind establishing if you have enough people to do the work. It has three main characteristics Timing of change, Magnitude of change and Attention to transitory phase. The main issue of Economies of scale is discussed in detail.

2.2. Service and Services Processes

The main reason for the growth of service sectors are Socio demographic trends, ICT, Globalisation and Outsourcing. The topic is introduced with Maslow's Hierarchy need theory. Characteristics of Services such as Intangibility, Customer Participation, Simultaneity, Perishability and Heterogeneity is given out. The process is one key element to define a service delivery system that can be classified as Visible vs Not Visible to the customer, Volume vs Variety, Processing of people, objects and information.

Shouldice Hospital limited case explains the services various operational responsibilities required. How the service has been provided and received has been seen. Customer Value equation is used to access more accurately the experience of a customer, which focuses mainly on the Value of the customer. In the case study various advertisements given out by the hospital are displayed and from feedback about them is discussed also a challenge has been given out by to the students which gives chance to innovation and applying of the strategies taught.

The Variability and Uncertainty in the demand will definitely affect the company's performance in such cases the company should learn to cope up with the market's needs. Decoupling is one of the major strategies to address this issue. The demand must be segmented in order to see where it is required to focus the efforts on and complementary services has to be developed to do better business and also in the

cases of seasonality. Critical issues of capacity management is laid out, shift scheduling and the importance of managing personnel during the higher demand times is seen. For such cases capacity buffer is necessary to manage operations.

Sharing Economy Service is an economic system based on the sharing of underutilized goods or services for a fee or for free directly (managed) by individuals. It as an economic model in which goods and resources are shared by individuals and groups in a collaborative way such that physical assets become services. The access that allows the resource's usage only for the required time period in addition to it has Peer-to-peer, Platform and On-Demand Services. Economies of scale and switching costs. Various real time examples which uses these operations is analysed. The concept of Dynamic pricing is given importance which gives profits for the organisation.

2.3 Queue Management

A queuing system is formed by one or more customers waiting to be served by one or more servers. It deals on modelling a system to understand which are the main criticalities of a company and where they are concentrated. Also how queuing theory supports companies, especially service ones to take better operation decisions on bottle necks or waiting time etc. And finally deals with how to improve the service level of their customers managing throughput time. Configuring the queue formed is an important task in order to manage. It can be analysed by three different systems such as Deterministic Analysis, Queueing Theory and simulation. Kendall's codification is described briefly and extended further. Knowing Psychology of waiting of the customers is crucial for having best satisfaction.

Digging deeper modelling of complex system with queuing theory is explained with a lot of numerical examples. M/M/C queueing configuration is given much importance as it is widely used in the industries and is more efficient than M/M/1. Priority rules can customise specific service for specific products by keeping the average performance same.

2.4. Lean Management

Lean management has become a universal management tool for delivering value and optimizing workflows. Learn what the Lean methodology and its benefits are. The Lean methodology relies on 3 very simple ideas, delivering value from your customer's perspective, eliminate waste (things that don't bring value to the end product) and continuous improvement Lean has proven to be an effective model for managing teams in some of the most demanding industries, like software development, manufacturing, construction, and many others. A huge role in this has

the fact that the methodology is simple to understand and quick to make an impact when implemented properly.

The 5 management principles of lean are

1. Value Identification which is distinguishing the value-adding from waste activities. It is crucial for everybody to be on the same page about it, so this should be a collective activity.
2. Map Value Stream i.e., visualising the work flow by giving out the value adding activities to finally reach the customer or vice versa. Kanban board is useful for doing mapping.
3. Creating a flow since any kind of waiting is a waste, when creating a flow of value, your goal is to ensure smooth delivery from the second you receive an order to the moment when you deliver it to the customer
4. Establish Pull which is starting new work only when there is a demand for it or there is a spare capacity and not over producing it.
5. Continuous Improvement can be achieved with the help of methods such a Plan-Do-Check-Act.

Value-stream mapping, also known as material and information flow mapping is a lean-management method for analysing the current state and designing a future state for the series of events that take a product or service from the beginning of the specific process until it reaches the customer. A value stream map is a visual tool that displays all critical steps in a specific process and easily quantifies the time and volume taken at each stage. Value stream maps show the flow of both materials and information as they progress through the process. Whereas a value stream map represents a core business process that adds value to a material product, a value chain diagram shows an overview of all activities within a company. Other business activities may be represented in "value stream diagrams" and/or other kinds of diagram that represent business processes that create and use business data.

A large number of examples are discussed to show the application of VSM in which both current state and future state of the companies are explained very thoroughly and also assignments are given to increase the experience of the students to face the real time situations.

Lean manufacturing is introduced, which is a production method designed to help reduce both the time for production, as well as response times to customers and from suppliers. The strategy aims to increase efficiency by eliminating waste, optimizing processes, and cutting costs. The practice allows reducing waste and inventory costs by producing only what's in demand and not overstocking. By reducing the production time, the method improves the productivity rate and helps

increase profits. The Toyota Production System (TPS) or “The Toyota Way” is an operational model which emerged in the early 20th century in Japan as a management system for organizing manufacturing and logistics processes. The backbone of TPS is the just-in-time production (JIT) system, created by Mr. Taiichi Ohno (a Japanese industrial engineer and businessman).

2.5. Yield Management

Yield management exploits information of customers behaviour obtained by operations department while delivering the service which allows the improvement of competitiveness of the company. The main mantra is “sell the right capacity, to the right customer at the right time at the right price” to maximise profits. This is applied in the Service companies. Tools used by yield management are Capacity allocation which in turn has Price policies, Demand forecast and Protection policies are laid out. Also processing in the case of Over booking is given.

The important decisions that are needed to be taken while using this concept are given out such as the safety level capacity you want to protect. Amount of over booking that you wish to have. A guideline to decide which requests you will accept and which one are you going to decline.

Protection level definition is found out using Marginal analysis and Heuristic Expected marginal Seat Revenue (EMSR). Several case studies are seen to find out the level in various service sectors. Also extended the usage to all the cases where you protect some capacity for more profitable customers who arrive late. Ryan Air case is used to see the real time application of this concept of Marginal Analysis.

Overbooking is used in a situation where it is done due to the fact that not all bookings become a sale. Overselling due to the fact that not all of the ones who bought the ticket use the services. It is applied where we can afford to accept number of reservations higher than the service that is able to provide by considering the effects of No Show. Can be considered either statically or service level depending on attention to image costs.

2.6. System Physics

The main take aways from the topic in on how to perform a Production Feasibility Analysis for both Decoupled and coupled systems. Considering C/O, C/T and A of different stages composing the system. Interpreting and see stocks and design the batching policy. And finally finding out the system’s flexibility and

improving it. In order to have more time to produce, companies usually use batch production of each single product. Batching can be done by either the quantity or time of batching. Further the examples are given out comparing the both batching and reducing setup times where in some cases it is seen that batching is useful and not in others.

Apart from the content of the syllabus, there are number of numerical examples and five important case studies that are done to apply the content taught in a real time scenario. A small project work is given to the students with an addition of few marks to the final grade which instigates the enthusiasm to learn and apply the concepts, although that is not a mandatory assignment it is just an optional one. The entire lecture has been recorded and made available for the students who cannot attend the class in presence due to covid restrictions. Availability of recordings made it very easy to access the course content so that a student can visit it any time and refer to the class. Paying attention to the lecture more than taking a note is always beneficial. By just mentioning the key words and the context the student can rewatch that particular episode where the point has been discussed.

To end the course a sum up class is given where exam pattern and the key learnings from the course are said and an example numerical is given out as a self-assessment to be ready and prepared for the examination.

CHAPTER 3: DATA OF OPERATIONS MANAGEMENT IN OTHER TOP TIER UNIVERSITIES

Operations management is one of the main functions of the industry for planning, organizing, and supervising in production and manufacturing. It is delivery-focused, ensuring that an organization successfully turns inputs to outputs in an effective manner. The inputs represent anything from materials, equipment, and technology to human resources such as staff or workers. It has firm foundations in supply chain management and logistics. Understanding global trends in supply chain management to meet client demand is often critical. With logistics, the careful and considered use of resources, as well as cost-effectiveness, has become increasingly important in an era in which resources can often be in short supply and customer expectations have skyrocketed, by considering all these factors universities around the world have been teaching Operations and related fields. The following are a few of the top universities and its take on the operations management.

3.1. Massachusetts Institute of Technology

Massachusetts Institute of Technology commonly known as MIT is one of the top academic institutions in the world for its research, development of modern technology and science present in Massachusetts in United States of America.

Under MIT'S Sloan School of Management it teaches students the importance of operations management in the industry with the help of its course under which it emphasizes on topics such as

3.1.1. Introduction to Operations Management

The course starts with the basics of operations and its importance. Operations is the work of managing the inner workings of businesses, so it runs as efficiently as possible. Whether making of products, selling products, or providing services, every small business owner must oversee the design and management of behind-the-scenes work.

The specific definition of operations will depend on your industry and the stage business is in. Sometimes, improving operations means thinking strategically about your systems and processes. Other times, it means being part of the on-the-groundwork to bring every aspect of a project, from tiny to huge, to reality. By considering this situation we can say operations has become an important function of every business which cannot be neglected.

3.1.2. Project Management

Projects are chronically late, over-budget, and fail to meet quality standards and customer requirements. In such cases Project management comes to rescue which is an application of processes, methods, skills, knowledge, and experience to achieve

specific project objectives according to the project acceptance criteria within agreed parameters. Project management has final deliverables that are constrained to a finite timescale and budget.

In industries production of new product or development of product have similar time constraints to deliver the product within the time limit. In this course of operations management of MIT, students to learn the importance of Time deliverables, quality. Clock speed is one of the methodologies which comes under dimension of time on operations management help the participant present in the project understands the evolution of technologies and make it use in project management, in order to understand the product development process case study of dremcast product by sega is considered which helped to understand value of project and its significance in company's future either in sales or brand value.

3.1.3. Operations strategy

When we consider completing an action, we formulate a strategy to achieve our end goal, similarly, to complete a process within given time in the organization we use tend to create strategy which can be considered as operational strategy which is obtained by key design parameters, planning, control, improvement in the tasks carried out. University helped students to understand this concept by assigning a task of checking out the case of burger king and formulate a strategy for its smooth sales and operations.

3.1.4. Inventory Management

This topic teaches about the process of ordering, storing, using, and selling a company's inventory. This includes the management of raw materials, components, and finished products, as well as warehousing and processing of such items. A company's inventory is one of its most valuable assets. In retail, manufacturing, food services, and other inventory-intensive sectors, a company's inputs and finished products are the core of its business. A shortage of inventory when and where it's needed can be extremely detrimental.

To check the inventory level MIT uses newsvendor model, which is a mathematical model used to determine optimal inventory levels.it is characterized by fixed prices and uncertain demand for a perishable product. case study on intel inventory has been taken to understand this concept and how it controls its inventory.

3.1.5. Process Technology

Process technology is the software with tools including digital platforms and Intelligent Process Automation (IPA) which is used to efficiently and intelligently create and deliver products and services, as well as improve speed and agility of

processes across the enterprise. Process technology can be used to automate and simplify workflows and accelerate business processes. It can also improve accuracy, quality, and reliability of those processes, helping companies operate with greater agility so they can be more flexible and adaptable to shifting business and market priorities. process technology also plays a key role in reducing costs across business operations. The case study of Alaska Airlines has been taken here since it adapted to process technology that has started self-service through technology which provide sustainable competitive advantage for it.

3.1.6. ERP Systems

ERP stands for enterprise resource planning is a software that helps businesses integrate and manage the different functional areas such as finance, marketing, operations and human resources to gain resilience and real-time agility and for growth. Organizations use ERP also for procurement, project management, risk management & compliance and supply chain operations.

ERP systems will also provide transparency into business process by tracking all aspects of production, logistics, and financials. These integrated systems act as a business's central hub for end-to-end workflow and data, allowing a variety of departments to access.

In almost every big manufacturing industry now a days there is the usage of ERP system which helps industry to manage different function easily without increasing its labour force on the administration process.

3.1.7. Process analysis

Process analysis is a review of all the procedures and steps that have been followed systematically to perform a given activity. It is a description of the way work is done in an organization. The process analysis is also known as an ongoing improvement process that analyses the way things are done to find effectual methods of performing that task.

The objectives of process analysis are to identify the elements that make it difficult to understand the process, identifying the completeness of the process. Remove any bottlenecks from the process, find redundancies, determine the allocation of resources, and finally check out the processing time.

3.1.8. Process quality

The quality assurance procedures, methods and mechanisms that assure consistency and control in producing a product or service. It also includes appropriate reviews, tests, and reports that provide for process evaluations and continuous improvements, also considering concepts of queueing, little's law is been thought to develop the understanding of process quality and also some numerical examples around little's law has been thought.

3.1.9. Queueing systems

The Queueing systems are simplified mathematical models to explain congestion. Broadly speaking, a queueing system occurs any time 'customers' demand 'service' from some facility; usually both the arrival of the customers and the service times are assumed to be random. If all of the 'servers' are busy when new customers arrive, these will generally wait in line for the next available server. Simple queueing systems are defined by specifying the following (a) the arrival pattern, (b) the service mechanism, and (c) queue discipline. From the probabilistic point of view, properties of queues are usually derived from the properties of stochastic processes associated with them.

Queueing models do not predict the customer waiting times with great accuracy because there could be one or more of the assumptions underlying the model was seriously violated, or it could be that inaccurate data was reported the case, but these models provide a structure for thinking about the operating systems. On the topics of the queueing model there are some case studies in the course for better understanding of operating system.

3.1.10. TQM process capability

TQM stands for Total Quality Management, in this course of operations management TQM plays a major role which explains the different levels of quality and about the information and measurement systems for organizational management. The different levels of quality are based on fitness for standard, use, market and latent requests.

The tools used in the topic helps for checking the process capability, quality decisions and also for data analysis are pareto Analysis, Process flow chart, Fishbone (Cause & effect) diagram, histograms, control Charts and lastly scatter plots.

3.2. Harvard Business School

Harvard business school in the Boston, United states of America. It has three different kinds of courses useful for us to benchmark. The main Operations Management course of Harvard business school consists of different topics as well as different cases taken with each topic and the takeaways are as follows

CL.#	Case	Lecture	Takeaways
1	The Future of Operations	Introduction to Operations	One of the Basic pillars in the activity of the company

2	McDonalds	Service Processes Average vs. Peak Demand	1. focus on the customer, 2. consider the customer's journey sequence 3. consider each staff role within the service 4. Allow for flexibility
3	Benihana of Tokyo	Object Oriented Design	Value the customer needs Design respect to customer requirements
4	ACME Medical Imaging	Operations Collaboration	Engagement of every key character for product development or service is most important for effective outcome
5	Medisys Corp.	Service Delivery Optimization	1.Aligning customer service strategy to customer experience strategy 2.understanding customers expectations of service quality 3. Choose technologies that empower agents to deliver outstanding experiences 4.Remember to recognize customer service agents
6	Pharmacy Services at CVS	Customer Interface	1.Establish an easy service flow 2.Minimizing the movement of the customer through process 3. Maximize the customer's comfort 4.keep customers in view
7	Virginia Mason Hospital	LEAN in Healthcare	1. Helps to Produce more defect free health care

			<p>2. Helps to reduce/eliminate waste and have more time to take care of patients</p> <p>3.Helps to improve workplace appreciation</p> <p>4.strengthens leadership</p>
8	A Measure of Delight	Quality Management	<p>1.Engagement of people</p> <p>2.customer focus and customer satisfaction</p> <p>3.Continuous improvement</p> <p>4.Measurement of quality</p> <p>5.Continuous improvement</p> <p>6.fact-based decision making</p>
9	Cisco Systems On NPI	Competitive Strategy	<p>1.Differentiation</p> <p>2.cost leadership</p> <p>3.market segmentation</p>
10	Sport Obermayer	Managing the Supply Chain	<p>Maintain visible supply chain</p> <p>The customer is crucial</p>
11	ZARA Fast Fashion	New Product Introduction	<p>Understand customers needs</p> <p>Right target audience</p> <p>Time is the crucial asset</p> <p>Engagement with the customers</p> <p>Provide good service</p>

Table 1. Operations management syllabus of Harvard Business school

3.2.1. Sustainable Business Strategy

Sustainable Business Strategy course provides participants with the knowledge and tools to become purpose-driven business leaders. This course explores the different business models that companies can use to drive change and explains why purpose-driven businesses are particularly well positioned to tackle the world's

biggest problems. You will learn how to influence management and other key stakeholders on the competitive advantages of being a purpose-driven firm, and how to integrate your values into your work so that you can help transform firms into catalysts for system-level change. This course topics is as follows with the given studies

Modules	Case Studies	Takeaways	Key Exercises
The Business Case for Action	Unilever Walmart Transatomic Power	Understand the business case for change and apply business models that create shared value Analyse industry disruptions and business uncertainties and create scenario analyses to develop smart strategic options	Business model and stages of disruption identification exercises
Driving Change at Scale: Moving Beyond the Firm	Walmart Unilever King Arthur Flour	Understand what purpose-driven firms are and why they are successful Examine the “Wheel of Change” and how business is a key catalyst to solve large global issues like climate change and income inequality Analyse cooperative action examples to understand how and why firms cooperate and why it’s necessary to enact change	Public good simulation game Prisoner’s dilemma analysis
Purpose-Driven Systemic Change	Norsk Gjenvinning King Arthur Flour Unilever	Analyse the investor’s role, including the role of stakeholder management, alternative governance, Environmental, Social &	Values and purpose reflection exercises

		<p>Governance metrics, and impact investing</p> <p>Evaluate the role of governments and other institutions in large-scale change and understand why “Systems Thinking” is necessary</p> <p>Develop a personal plan for what YOU can do</p>	
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Table 2. Sustainable Business Strategy Syllabus of Harvard Business School

3.2.2. Global Business

This Course helps students and different participants assess opportunities, mitigate risk, and create and capture value for their organization. The course explores the economic, political, and social factors driving change, and participants will learn how to take decisions.

Modules	Leaders Interviewed	Takeaways	Key Exercises
Macroeconomic and Political Analysis	<p>Bryant Ambelang, NatureSweet</p> <p>Craig Boyan, H-E-B</p> <p>Cynthia Carroll, formerly of Anglo American</p> <p>Christopher Finn, The Carlyle Group</p> <p>Andrew Gilchrist, formerly of Egon Zehnder and <i>Financial Times</i></p>	<p>Interpret data on countries’ macroeconomic and political performance</p>	<p>Unidentified Countries Exercise (Measuring and Interpreting Economic Indicators)</p>

	<p>Ellen Guidera, Portillo Ski Resort and Tierra Hotels</p> <p>Ray Mabus, former US Secretary of the Navy</p> <p>Anand Mahindra, Mahindra Group</p>		
Economic Conditions and Your Business		<p>Understand effects of taxation, government spending, and monetary policy on the business environment</p>	<p>Current Accounts, Financial Accounts, and a Country's Strategy</p> <p>Hedging Exchange Rates</p>
Political Order and Disorder		<p>Understand the role of government in the modern economy</p> <p>Analyze political risks to business strategy</p>	<p>The Median Voter Theorem</p> <p>Sources of Long-Term Growth</p>
Business and the Interconnected World		<p>Understand how cross-border flows of goods and capital affect firms' and nations' competitive positions</p> <p>Analyze effects of environmental change on the competitive landscape</p>	<p>Absolute vs. Comparative Advantage, the Production Possibilities Frontier, and Trade</p>

Table 3. Global Business syllabus of Harvard Business school

3.3. COLUMBIA BUSINESS SCHOOL, COLUMBIA UNIVERSITY

Columbia Business school being one of the most famous business school's present in the New York city teaches its students operations management course and its main topics with key-takeaways are given as follows

	Topics	Key takeaways
1	Introduction	One of the Basic pillars in the activity of the company
2	From process analysis to valuing improvements at Aroma Consumer Products	1.consider customer journey sequence 2.Aligning customer service strategy to customer experience strategy 3.understanding customers expectations of service quality 4.Choose technologies that empower agents to deliver outstanding
3	Scaling Operations via new process design at Happy Family	1.engagement with everyone 2.considering customer needs 3.Design respect to the customer
4	The impact of variability on process performance and approaches to mitigate it	Its important to always remember that is variation that people feel and mitigating variability with pragmatic tools
5	Managing waiting times in services	Providing customer personal services manages the waiting time
6	Introduction to supply chain management: Newsvendor model	Newsvendor model used for determining the optimal inventory level and alert the user regarding the low inventory.
7	Mitigating the impact of uncertainty through risk pooling at GE	Centralization of inventory decreases the uncertainty in the sales at retail
8	Processes conformance: Quality management and the concepts of process capability, 6-sigma	Understanding how to measure define analyzing, improve process and control the production variance and

9	Improving processes and monitoring performance: Statistical Process Control	Usage of control charts, bar graphs, for analysis of the data from processing cycle
10	Lean operations: a framework for operational excellence	1.delivering value as defined by the customer, 2.eliminating waste, 3. continuous improvement.

Table 4. Operations Management syllabus of Columbia Business School

3.4. TU DELFT

DELFT university of technology also referred as TU DELFT present in Netherlands, In the university of TU delft the take of operations is based in the stream of mechanical, maritime and materials engineering.

Operations and maintenance: This course focus on intelligent control for optimizing the operational performance and for maintain the reliability of multi-machine systems in large-scale logistics and transport domain. Along with the understanding of diverse transport systems and logistic processes, including the dynamic interactions of the equipment and facilities involved, the control for multi-machine systems contains two folds, the integrated control for efficient operations and the intelligent decision-making for reliability control. To ensure efficient and reliable operations at both equipment level and system level, technologies and methodologies of automated data acquisition, remote communication, intelligent data analysis and integrated operational decision-making will be studied. Condition-based maintenance of systems and equipment will be analysed and discussed in combination with on-line techniques for monitoring the health of the sensors used for maintenance. During the course industrial case studies will be given to present the state-of-the-art development and foreseen challenges. The course is concluded by practical assignments where such intelligent control systems will be researched and conceptually designed.

From all these data the following are key takeaways of the course.

- Key take aways:**
- Understanding of the complexity of the operations and interactions of multi-machine systems;
 - Identification of the properties that determine efficient operation and reliable performance;
 - Understanding of the concept of intelligent control for operational support systems and advanced maintenance

strategies;

- Analysing and modelling the interactions and operational processes of multiple equipment and facilities;
- Designing the intelligent control system in term of mathematical models and integrated control methods;
- Appling the methodologies of assessing the efficiency and reliability of both individual machine and overall multi-machine system;
- Understanding the basic concepts of on-line fault diagnosis with respect to detection, isolation and identification;
- Designing the methods for sensor fault detection and isolating multiple sensor faults.

3.5. Wharton Business school, University Of Pennsylvania

University of Pennsylvania one of the oldest institutions present in the United States of America known for its academia, commerce, arts and science teaches operation management and related courses through Wharton business school and trough online course platform coursera.

Wharton business school has an Operations Strategy course which mainly focus on the topics related to different strategy modulations for the purpose of the free movement in the operations of the company, main topics which are emphasised in this course are as follows

s.no	Topic	Key-takeaways
1	What is operations strategy	One of the Basic pillars in the free activity of the company
2	Betting on the unknown: Newsvendor model	Newsvendor model used for determining the optimal inventory level and alert the user regarding the low inventory.
3	Newsvendor Applications: Managing Biases in Operations Decisions	By looking into the low inventory level the newsvendor application notifies the trade directly

4	Second Chances: Speculative and Reactive Strategies	Commonly used in the fashion, retail supply chain industries where the order is contracted before.
5	More of less or less of more: Make to Stock vs. make to order strategies	It all depends on the consumer demand if the demand is uncertain make to order fits bets rather than other make to stock with anticipated demand.
6	Sourcing strategies: Off-shoring and in-sourcing	The decision of off-shoring or in-sourcing depend the cost of the material or process in the local area compared to off-shoring
7	Operations risk management Strategies	1.risk identification 2.risk assessment 3.measurement and mitigation 4.monitoring and reporting
8	Technology: Product Design and Clock speed	Product design and clock speed depends upon on the changes occurring in the technology
9	Operations on the internet	1.Usage of cloud computing for running the machines located faraway
10	Revenue Management: Pricing Strategies	The pricing strategy depend upon the customer characteristics and needs
11	Coordination and Information Sharing Strategies	This strategy help in the development of new synergies or lead to the development of new product.

Table 5. Operations Strategy syllabus of Wharton business school

In the Coursera platform Wharton business school teaches a course introduction to operations management which mainly focuses on the topics as follows

S.no	Topic	Key takeaways
1	Introduction of the course	Understanding what operations and four dimensions of operational performances is

2	Process Analysis	<ol style="list-style-type: none"> 1. Finding the bottle neck 2. labour cost and labour utilization 3. little's law 4. make to stock vs make to order
3	Productivity	<ol style="list-style-type: none"> 1. financial value of productivity 2. key performance indicators and kpi trees 3. productivity ratio 4. overall equipment effectiveness
4	Quality	<ol style="list-style-type: none"> 1. Reasons of defects 2. Quality and flow 3. Six sigma 4. Control Charts

Table 6. Introduction to Operations Management syllabus at Wharton Business School

3.6. Haas School of Business, University of California

Under university of California, Berkeley Haas school of business offers a course on operation management. The various topics covered are as follows

	Topics	Key take aways
1	Process Analysis	It helps businesses uncover inefficiencies and plan changes to improve things
2	The Service Factory	Focus on the customer service
3	Services: Design, Delivery and Responsiveness I	<ol style="list-style-type: none"> 1. Focus on the Customer needs. 2. Considering the sequence
4	Services: Design, Delivery and Responsiveness II	<ol style="list-style-type: none"> 1. considering each staff role within the service 2. Allow for flexibility.

5	Sharing Economy Platform Operations	<ol style="list-style-type: none"> 1.It involves short-term peer-to-peer transactions to share use of idle assets or to facilitate collaboration 2.It always involves some type of online platform that connects buyers and seller
6	Experiential Supply Chain Exercise; Operational Transparency	<ol style="list-style-type: none"> 1.increased employee engagement 2.fewer barriers to innovation 3.clear-eyed leadership
7	Supply Chain Exercise Debrief; Bullwhip Effect Economic Order Quantity	<ol style="list-style-type: none"> 1.Demand forecast adjustments 2.fluctuations in prices 3.EOQ helps to maintain a consistent inventory level and to reduce costs
8	Betting on Uncertain Demand	<ol style="list-style-type: none"> 1.Betting might lead us to reward the wrong things
9	Ecommerce Operations	<ol style="list-style-type: none"> 1.Growing E-commerce demand, growing challengers for retailers 2.retailers lack automation
10	Supply Chain: Responsiveness and Responsibility	<ol style="list-style-type: none"> 1.Increasing access to data leads to better decision-making
11	Revenue Management; Littlefield Simulation Debrief	The pricing strategy depend upon the customer characteristics and needs

Table 7. Operations Management syllabus of Haas School of Business

3.7 ETH ZURICH

ETH Zurich one of famous public research university in the city of Zurich, Switzerland. From this university we were only able to find data of course not the syllabus. Production and operations management: The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

This course is concerned with the business processes that transform input into output and deliver products and services to customers. This course explains that is much more than what takes place inside the production facilities of big companies like

ABB, Boeing, BMW, Toyota, and many more to mention a few. Also Business involved in finance, professional service, media, and non-profit organizations, and public service companies which dependent on their operational capabilities.

The following three fundamental areas in which the course topics are covered: (1) Introduction to POM and operations strategy. (2) Operations design and management, including demand and capacity management, production planning and control, the role of inventory, lean management, service operations, and performance measurement. (3) Operations improvement, including problem-solving and the use of new technologies in POM ("Industry 4.0" / digitalization). The outcomes of this course are expected of learning a range of useful concepts, principles, and methods that can be used to design, analyse, and improve value-creating processes.

This course is concerned with the productivity of technology, people, and processes. Hence, this course is considered as a generic research field, relevant to all business sectors. Many of the examples and concepts of this course from the manufacturing sector, which for many years have been subject to global competition and learned how to develop effective and efficient operations.

3.8. NATIONAL UNIVERSITY OF SINGAPORE

The National University of Singapore (NUS) is one of the famous university in world and is a national research university in Singapore. NUS provides a course related to operations that is operations strategy which mainly focuses on the topics like operations for strategic advantage, quality, re-thinking process analysis, valuing a company's operation, forecasting, managing uncertainty, emerging topics of operations, agile supply chain and managing a global supply chain, Business Model Innovation and disruption workshop.

We have seen few of the topics of the course by NUS are similar to the ones that is discussed above before, now we are going to understand few topics as follows

3.8.1. Emerging topics of operations

- Due to the recent pandemic situation, usage of internet and increase in the connectivity, a sudden growth for the e-commerce industry in all sectors and due to this there is an increased level of collaborations in the industries and there is a reduction in the transaction costs.
- Technology can be also considered as emerging topics of operations because due to development there is production and innovation around computer aided systems which can used for doing the machinery process without much human effort and can also be helpful in decrease the lead time

- Globalization helped organizations to enter the different markets around the world but if there is a no operations team in the new country then it might lead to problems
- Sustainability is one of the main factors considered now a days to cope up with the global warming situation and also to protect the world.

3.8.2. Agile supply chain

Agility refers to speed and efficiency. This type of supply chain is focused on speed, cost efficiency, responsiveness, Productivity and flexibility in the production and delivery of goods.

These Characteristics such as system of product distribution that is concerned with doing things quickly, saving costs, maintaining flexibility, being responsive to the market and consumer demands, and keeping productivity at all-time highs defines what is an agile supply chain.

Agile supply chains rely on real-time data to help make decisions in day-to-day operations, as well as projected data in supply forecasts. Combined, it creates a more robust process that saves businesses and consumers money, eliminates waste of excess inventory, foresees potential shortages, and does it all quickly and productively. With agile supply chain, flexibility is key.

3.8.3. Global supply chain:

As the name suggest as global which refers to the whole world, similarly global supply chains are networks that can span across multiple countries and continents with a purpose of sourcing and supplying goods and services. Global supply chains involve the flow of information, processes, and resource across the globe.

A global supply chain utilises low-cost country sourcing. It's the procurement of products and services from countries with lower labour rates and reduced production costs than that of the home country. A global supply chain will usually flow from your own organisation in your home country as a buyer across your supplier tiers; it's these suppliers who will be located in other areas of the globe.

CHAPTER 4: BENCHMARKING

Benchmarking is the practice where an organisation or a business is comparing its key metrics of their operations to other similar companies which does the similar kind of operations and functions. Companies use benchmarking as a way to become more competitive. By looking at how other companies are performing, one can identify areas where they are underperforming. Companies will be able to identify ways they can improve their own operations without having to recreate the whole strategies or processes. They are able to accelerate the process of change because they have models from other companies in their industry to help guide their changes.

Benchmarking occurs in all types of companies, including private, public, non-profit, and for-profit, as well as in industries e.g., technology, education, and manufacturing. Many companies hire a person to a position or offices in the company that are in charge of performing benchmarking analysis. Some of the positions include:

- Institutional researcher
- Data analyst
- Consultant
- Business analyst
- Market researcher

4.1. Benefits of Benchmarking

1. Competitive Analysis

Businesses usually strive to enhance their execution tenfold. Every company wish to improve their business by benchmarking their existing performance against competitors. By using this way of benchmarking in doing competitive analysis has allowed businesses to gain strategic advantages over competitors and grow in industry averages.

2. Monitor Performance

Benchmarking involves projecting future trends by looking at current trends in data and also depending on what business aim to achieve. In order to know if business has been successful, benchmarking needs to be a continuous process. Monitoring performance is an inherent characteristic of it.

3. Continuous Improvement

The aim of benchmarking is to improve a certain element of a business which is similar to monitoring performance, thus we can say continuous improvement is an essential attribute of benchmarking. This improvement should not be considered as something that improves once and is forgotten, but something that improves over time and is continuous.

4. Planning and Goal Setting

Goals and performance metrics are set in order once benchmarking has been carried out to improve performance. These goals are new, which have more competitive targets for a company, but they must be achievable. If goals are unrealistic to achieve teams become demotivated and goals are destined to remain unfulfilled.

5. Encourage Ownership

When companies look at their processes and metrics, they need to ask hard questions to get all the answers which are needed. This includes talking to everyone in the business and understanding their roles. By asking various questions about their role and gaining a better understanding of everyone's role, ownership for processes and performance should be encouraged, so it can lead us to better performance and higher-quality end results.

6. Understand Organisation's advantages

Benchmarking identifies where the business performance is right now compared to where business owners want it to go. If any company owners are looking at improving any process in their business, benchmarking is a way of looking at how they can excel and become more successful through outlining the steps needed to achieve the goal.

4.2. Need of Benchmarking in Operations Management

Benchmarking in educational system allows us to understand the level of course content delivered when compared to the other competitor universities which deliver the same or similar courses. It is very essential to keep updated in the current trends and practises that are to be performed. After graduation the student is set free in the world where he has to compete with the people graduating from a Top Tier university, in such cases the candidate must have been given the similar or even better knowledge and idea regarding the particular domain in the industries.

Due to Covid a vast change in the industry has seen where Operations management played a vital role in having almost impossible way of functioning with all the lockdown and border rules all across the world. Several universities are very dynamic in nature to update their course content according to the current trends.

Comparing them and finding out which of the among is leading or has the best possible topics discussed gives a greater advantage for a student by including the leading point to the current state syllabus. The exact point of lack is found out and rectified to be in a healthy competition. It is technically not possible for us to include all the topics considering the time constraint and other challenges such as work load for the student.

The case studies and examples used gets outdated if not updated. It is always better to compare and take ideas from rivalries and develop a better numerical or theoretical case studies. In order to do the proceedings we find the data about Operational Management course in Top Universities such as MIT, Harvard etc., separate, segregate and sort the information in a way that can be utilised by us. We can see that there are many changes in topics, additional topics have been discussed and some are skipped.

4.3. Findings

The course at Politecnico di Milano is short and precise, It does not include various topics which are essential according to the other colleges. There are ample amount of exercises present to understand the basics of the few concepts that are taught. 60% of the time of lectures is used to explain theory and the basic numerical exercises and case studies, rest of the time is allocated for practise sessions where one can solve and check various examples finding out different ways of approach to obtain a solution.

Here we create a table where we compare the data found from different universities in various aspects. Firstly we list out the key topics that are discussed in the course. Not all focus on the same topics, the main common topics are eliminated and the rest are seen under. The next aspect we compare is Institutional effectiveness where we get to see the evaluation procedure of the course and the understanding level of the students by assessing them. We then see the methodology used to teach the course. Some of them use Flipped classroom method which is very interesting and interactive, this method has proven the maximum interaction between the tutor and the student. Having seminars and project works will also improve the knowledge on the topics. The student survey has been taken next and we ask them the experience they had while learning the course. The university which has the hands-on industrial experience has proven to have the best results. At the end we see which practice is best and then implement it to our course or maybe improvising it more is always a better idea.

UNIVERSITY NAME	KEY TOPICS	INSTITUTIONAL EFFECTIVENESS	STUDENT EXPERIENCES	METHODOLOGY	INDUSTRIAL EXPOSURE
Poltecnico Di Milano	Operations strategies, Lean management, Yield management, Queue management	At the end of semesters Students are evaluated based on their problem-solving skills and understanding of the lectures with the help of examination	Students understand and try to solve industrial problems with the help of Case studies, brain storming.	Lectures (offline & Online), Discussions, Demonstration, Assignment.	NO
Massachusetts Institute of Technology	Operations strategies, Project management, Inventory management, Process technologies, ERP systems, Queueing systems, TQM process capabilities.	Students are evaluated based on their group presentation with 30% and three case-writeups on the industrial problems, with 20%,25%,25% weightage on final grade	Student experience industries through virtual industrial visits, solving case studies and by attending seminars	Lectures (offline & Online), Discussions, Seminars, Demonstration, Assignment.	YES
Harvard University	Operation strategies, Service processes, Object oriented design, Operations collaborations, Service delivery optimization, Lean management, Quality management, New product Introduction, Revenue management, Global business	Students are evaluated after each topic by help of questionnaire and by their capstone project at the end of the semester.	Student experience industries problems through solving case studies	Lectures (Online), Demonstration, Assignment, Flipped classroom.	NO

Columbia University	Lean management, TQM management, News vendor model, Process performance, Risk management, Statistical process control.	Students are evaluated on their group presentation at 40% weightage, self-case write-ups at 20% weightage and final exam at 40% weightage conducted at the end of the semester.	Student experience industries through industrial visits, solving case studies And by doing internships.	Lectures (offline & Online), Discussions, Demonstration, Project based learning	HIGH
TU DELFT	Operational performance, Transport systems, Logistic processes, Intelligent data analysis, Operational decision making, Conditional based maintenance.	At the end of semesters Students are evaluated with an exam at 80% weightage based on their problem-solving skills and understanding of the lectures also a group project with a weightage of 20%	Student experience industries by solving case studies, participating in industrial projects.	Lectures (offline & Online), Discussions, Seminars, Assignment.	YES
UNIVERSITY OF PENNSYLVANIA	Operation strategies, News vendor model, Make-to-stock vs make-to-order strategies, Revenue management, Risk management, Process analysis, Productivity, Quality analysis	Students are evaluated based on their group presentation at 30% weightage, class participation at 30% weightage and final exam at 40% weightage conducted at the end of the semester.	Student experience industries through industrial visits, solving case studies and by industrial projects.	Lectures (offline & Online), Discussions, Seminars, Demonstration, Assignment, Project based learning	OPTIONAL
University of California	Process analysis, Service factory, Sharing economic	Students are evaluated based on their Midterm at 20% weightage, Group assignment at	Student experience industries through industrial visits, solving case studies	Lectures (offline & Online), Discussions, Assignment.	YES

	platform operations, Operational transparency, Revenue management, e-commerce operations	17.5% weightage, 2 solo Written assignments at 17.5% weightage, class contribution at 10% weightage and final exam at 35% weightage.	and sometimes attend seminars and by doing internships with the company		
ETH Zurich	Operations strategies, Capacity management, Production planning and control, Inventory management, Performance management, Service operations.	Students are evaluated based on their group presentation of their case studies at 30% weightage and final exam at 70% weightage.	Student experience industries through virtual industrial visits, solving case studies and attend seminars of industry professionals	Lectures (offline & Online), Discussions, Seminars, Demonstration, Assignment.	YES
National University of Singapore	Demand Forecasting, Rethinking process analysis, Agile supply chain, managing uncertainty, Global supplychain	Students are evaluated based on their participation at 10% weightage, Group project at 30% weightage, Case and paper presentation at 30% weightage and final exam at 30% weightage.	Student experience industries through industrial visits, solving case studies and by doing industrial projects.	Lectures (offline & Online), Discussions, Seminars, Demonstration,	YES

Table 8. Benchmarking of Operations Management course at Top-Tier Universities

The main focus is on Value Stream mapping is observed referring to the course content both current and future state mapping is seen and it must be continued to have this as it is very important for finding out the value adding functions in a system. Lean management principles used for delivering value from customers perspective and eliminating waste. Continuous improvement has been found very effective and being used in almost every industry, a special dedicated team is assigned to work on this aspect in the industry. It is even applied to day-to-day activities.

Yield Management is another important topic of Operations management which is very beneficial for the service business units especially the term dynamic pricing is widely used. Studying the customer behaviours towards particular product or service we can exploit the behaviours and make the company be on the upper hand. The two major categories seen are Marginal Analysis and Overbooking in all the courses seen as it is one of the major and important subject when it comes to the benefit of businesses.

After taking the consideration of data from different universities and by evaluating different concepts and its uses in the present day, industry we can come into a Conclusion that there are few topics which synchronize more with the present day than compared to other topics. And few of them are coinciding with POLIMI course structure. The topics which are unique and different which can be added to the course are listed below and it is found to have a positive impact on the course content.

4.3.1. Revenue Management

Harvard Business school, Berkeley Haas and Wharton school of business have been teaching revenue management by considering the fact that revenue management gives high return to the clients which follow this model.

Revenue management is a business technique that enables the optimization of the inventories and maximizes profits. Its exact parameters evolve over time due to new artificial intelligence systems, processes, automation, and the general advancement of the industry-leading tools, but at its core remains the same.

Revenue management process use the performance data for analysing and to help hotel industry to predict the behaviour of its customers. The data is then utilized to make appropriate decisions regarding pricing and distribution strategies. The goal of revenue management is to have the right room at the right time and place. When this occurs, you will be more likely to maximize your revenue and it turn your profit.

The information gained on how customers think and perceive value will be ultimately used to match supply to the demand. This will help w to determine when it is best to hold onto a room until a higher price is achieved and also how to recognize a drop in demand and signalling the time for discounted rates.

The concept of revenue management was designed for the airline industry in the starting period so different companies could find ways to anticipate their customers' demands and needs, so the process can create dynamic pricing on it. Once the process has discovered, it was soon considered beneficial and applicable to any type of industry that involves customers who are willing to pay for same product with

different prices, when there is only a certain amount of a particular item to be sold, and it should be sold during a certain time, such as a hotel room.

4.3.1.a. Revenue management vs Yield management

Both yield management and revenue management are useful tools in the hotel industry. Yield management is a price strategy tool which helps a hotel to achieve a maximum turnover. In short, the data from bookings and competitors in the industry is used to find the right room for the right guest at the highest price, if possible. With yield management, hotel owners understand that selling the same product at different prices is a good pricing strategy. Factors such as dates of the stay and how early in advance the room is booked used for price distinction.

Revenue management is very similar to the concept of yield management, though it is considered much broader with the goal of optimizing the sales of the room so that the hotel revenues are maximized. Since it undertakes the action for overall revenue of a hotel, instead of some amount of turnover, it requires data analysis more accurately. To come up with a future forecast, data and key performance indicators are used. This forecast will not only involve room usage but also the other sales aspects of the hotel as well, such as revenue from spas and restaurants and gym.

The primary difference between the two is that you get the big picture with revenue management, while yield management provides you with the proper price optimization, which is just a small part of revenue management.

4.3.1.b. Applications of Revenue management:

Revenue management can be exceedingly important to a hotel as it maximizes the revenue by making the most out of room inventory. And this is all done by making calculated decisions from all the data available, instead of guesswork. Since hotels have fixed costs, whether their rooms are sold or not, they can make sure that they meet their costs and price their services to allow them to be profitable.

Revenue management apart from hospitality industry it is emerging as a popular strategy within the car rental companies, theatres, financial services, medical services and the telecommunications industry.

By understanding revenue management properly, we think that yield management method plays a small role right in increasing the sales or profit of the client so we suggest Politecnico di Milano to add the topic of revenue management to the course.

4.3.2. Vendor management:

Wharton school of business, Harvard business school & MIT have been teaching the vendor management topic in their course structure because in the operations the supplier plays a major role in running of business and this topic mainly emphasis in maintaining that relation between supplier and organisation.

Vendor management is used by organizations to oversee their vendors(suppliers). It undertakes activities such as selecting vendors, controlling costs, negotiating contracts, ensuring service & delivery, and reducing vendor-related risks. The vendors of company changes depending on the nature of the organization. Because companies can be as diverse as IT vendors, food suppliers, cleaners, and media consultants. Suppliers are also different based on their size from solo traders to large organizations.

For an organisation vendor management is important for many reasons. It plays a key role when it comes to selecting the vendor who is most appropriate for a particular need for running of business. In addition, companies use this type of management to achieve different goals, such as making opportunities for cost savings, as well as taking appropriate measures for improving the onboarding process.

Suppliers are need to be effectively managed so that it can reduce the risk of supply chain disruption and that way it make sure the goods and services provided are delivered at the expected date and time. Apart from this effective vendor management process helps companies to build stronger relationships with their vendors which may, in turn, lead to negotiation of better rates and create more opportunity.

Companies which use this type of managing method for its vendor selection gains the benefits such as better selection of vendors, applying cost savings, decreasing the time period of vendor onboarding, reducing the risk of disruption in supply chain, strengthening of supplier relationships and Increasing negotiation power.

The vendor management process includes a few different activities such as

1. Selecting vendors
2. Contract negotiations
3. Monitoring vendor performance
4. Monitoring and managing risk
5. Final payment.

4.3.2.a. Vendor management challenges

Companies with big supplier's base, and a giant geographical footprint, it can be difficult to obtain a centralized view on the suppliers of the company. Challenges occurs at different time period in the process of vendor management, it can be start from obtaining the right documentation from vendors for performing the necessary risk assessments. Because of the risk factor it is very important for adoption of suitable processes and tools to avoid any issues.

Business use this different type management strategies to ensure supplier relationships deliver the value intended, with much efficient processes. A strategy may include areas such as quantifiable goals and tracking KPIs and maintaining and building effective relationships with suppliers. Organizations and companies also classify their suppliers so that they can identify their strategic vendors and it make efforts to invest in the strengthening of those relationships. Other type of considerations includes in taking measures to avoid relying on a particular vendor.

Vendor management process is important since it contributes in the free flow of goods from the vendor to the organization without blockade of the goods and if this topic integrated into the Polimi operations management course I think it will elevate the Subject of operations.

4.3.3. New trends in operations

From the national university of Singapore and Wharton business school we were able to find the glimpse of this new trends in operations which are e-commerce, sustainability, globalization and increase in the technology

- E-commerce: In the recent years we can say that everyone become more addicted towards the online buying because of Pandemic situation and which in short disrupted the normal operational process and increased the collaboration between the operators and logistics agents.
- Technology have been emerging with increase in the innovations around the world and also usage of the machines in the operations made operators connect with the machines and which lead to short lead-time.
- Globalization has become famous after there is decrease of the political and judicial laws and increase in the universal open market, companies started to reach towards different markets and capture the new market.
- Sustainability is one of the main factors around which many international forums, world organizations and countries are making laws to regulate the use of plastic and also Companies are making initiatives to adapt sustainability.

4.3.4. News vendor model

Columbia business school considers news vendor model as one of the main topics in operations management where news vendor model used for determining the optimal inventory level and alert the user regarding the low inventory. This model is a mathematical model in applied economics and operations management that is being used in various industries for determining the optimal inventory levels. It is characterized by the uncertainty demand of a perishable product and its fixed prices. If the inventory level is X , then each unit of demand above the inventory level X is lost in potential sales.

These problems can be named as Newsvendor Problems because it is similar to the one of the major dilemma faced by the manager of a newsstand each morning for stocking newspapers. They are quite prevalent in the stocking of perishable goods, such as baked good, eggs, fresh pastas and noodles, vegetables and milk which must be discarded after the expiration dates. They also apply to seasonal products, which tend to be salvaged at the end of the season such as easter eggs. Fashion goods, such as designer jewellery and designer clothes, also exhibit Newsvendor economics.

The newsvendor problem is a business decision taken one-time which occurs in many different business situations such as:

- Buying seasonal goods for a retailer – Retailers have to buy seasonal goods once per season. (A “season” which can be a year, week, day, etc.) For example, most easter eggs can only be purchased seasonally. If a buyer orders too few easter eggs, the retailer will have lost sales and the customers are dissatisfied. If the buyer orders too many easter eggs, the retailer will have to sell them at a cheaper price or might have to throw some away.
- Making the last buy or last production run decision – Manufacturers have to make a last buy for a product that is near the end of its life cycle. If the order size is small, the firm will have stockouts and the customers will be disappointed. If the order size is large, then firm have to sell at salvage value.
- Setting safety stock levels – A distributor must set the safety stock level for an item. Stockouts will occur if safety stock is too low, and if the situation of safety stock is too high, the firm will have too much carrying cost. Nearly all safety stock models are like the newsvendor problems with the selling season being one review period or one order cycle.
- Setting target inventory levels – A salesperson carries inventor y in the trunk of a vehicle. The inventory is controlled by maintain a target inventory level.

Stockouts will occur if the target is too low. The salesperson will have too much carrying cost if the target is too high.

- Selecting the right capacity for a facility or machine – If the capacity of a factory or a machine over the planning horizon is set too low, stockouts will occur. The capital costs will be too high, if capacity is set too high.
- Overbooking customers – If an airline overbooks too many passengers, it incurs the cost of giving away free tickets to inconvenienced passengers. The airline incurs an opportunity cost of lost revenue from flying with empty seats, if it does not overbook enough seats.

4.3.5. Risk Management

Columbia business school, Wharton business school consider risk pooling and risk management as one of the important topics of their course structure because they believe in risk avoidance. The risk mainly focuses on risk identification, risk assessment, measurement and mitigation and lastly monitoring and reporting. While risk pooling focused mainly on the centralization of inventory which decreases the uncertainty in the sales at retail sector.

Risk management is one of the main processes for a company since it gives business with the tools for identifying and dealing with risks of high potential. Once tools identified the risks, then mitigating it can be easy. In addition, risk management provides businesses with a base which it can use in proper decision-making.

For a business, assessing and managing of risks is the best way to prepare for events which may occur in the way of growth and progress of a business. When a business evaluates its plan for handling the potential threats, then it develops structures for address them, and for improving its odds for becoming a successful entity.

Effective risk management is basically the process which company carried out or it attempts for controlling as much as possible for its future outcomes by engaging proactively than reactively. Therefore, we can say effective risk management makes the potential offers to reduces both the possibility of a risk occurrence and its potential impact. Identify, Assess, Control and Review control are the main steps in carrying out risk management. If the risks are found usually the company has three choices Avoidance, Mitigation and Acceptance.

CHAPTER 5: CONCLUSION

From this Benchmarking Analysis we are now able to find the key elements that has to be implemented in the Operations Management course of Politecnico di Milano, for creating a much better experience and knowledge for the student. The course structure of Polimi is absolutely perfect and in track with the current trends but it does not talk about few other important topics which are essential to be working on the real time industry. Vendor Management is one such field where you learn how to deal with the suppliers, Although Polimi has a different course teaching this topic in depth but a basic introduction to this will be appreciated.

Revenue Management is another topic which is very similar to Yield Management. By understanding revenue management properly, we think that yield management method plays a small role right in increasing the sales or profit of the client companies. Revenue Management involves the use of analytics and performance data to help those in the hotel industry to predict their customer's behaviour. The data is then utilized to make appropriate decisions regarding pricing and distribution strategies. News Vendors Model and Risk Management are two other key topics that has been discussed and has given a very high importance but since the chapters are vast the inclusion of it in the course is not well recommended.

Apart from course content, Flipped classroom method is suggested because it has the maximum interaction and maximum efforts from the student side. It is basically where the class is taken by students, each topic is discussed by an individual or a group of individuals. The professor can also add few points in between whenever necessary. A mandatory assignment with additional marks to final grade is highly effective to increase the enthusiasm towards the subject. Along with video lectures an industrial visit is essential for better understanding of the operations especially for Lean Management.

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