# Knowledge Management in Technical Education Using Lean Concept

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**ABSTRACT**

*Innovation, Flexibility and Rapid change - are the keywords for 21st century business environment. Industries that have traditionally delivered manufactured goods must streamline their processes and focus on the rapidly changing needs of their customers and the capabilities of their suppliers. Lean is one of the promising alternative strategy for achieving continuous improvement in business performance through identifying a company's value stream and then systematically removing all waste. Educational Institutions are now focusing on knowledge management, and knowledge is a new paradigm for the way of work. The key issue in knowledge management in educational institution is faculty-subject allocation problem which can be solved by using the lean concept. This paper mainly concentrates on minimizing the knowledge wastage in technical institution by properly allocating the faculty to subjects. The faculty-subject allocation problem is solved using a meta-heuristic approach and a decision support system can be developed.*

**Keywords**

*Technical Education, Knowledge Management, Lean Concept, Meta-Heuristics.*

## 1.0 INTRODUCTION

In the present technological scenario, the institutions have a commitment to provide the best education for each and every student to the needs of them. The engineering education must be designed to prepare students to match the future requirements of their customers, who are Higher learning institutions or Industries or Research organizations. For example, the curriculum should be flexible enough to satisfy the different requirements of different customers. The requirements of the customers are specific to their field and application. The specializations required by the customers of mechanical discipline are: (i) Design, (ii) Thermal, (iii) Production and (iv) Industrial Engineering. Figure 1 shows input-output model of Mechanical Engineering (ME) discipline.

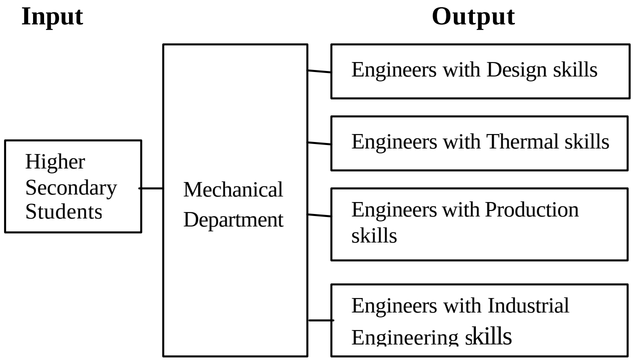


*Figure 1: Students graduated with different skills*

Faculty of any discipline, in general, possess basic degree in the same discipline and specialization in various fields of the discipline at their higher studies. In addition, their experience will be varying in nature such as years of experience, industrial exposure, subjects handled in the past, research and so on. The knowledge of the faculty helps to a great extent to impart skills that the students acquire during their course and it should not be wasted. The allotment of subjects to faculty plays a vital role in the faculty knowledge usage and student skill acquisition process (Partiban et al, 2004). Proper allocation would result in higher usage of faculty knowledge and hence higher skills to students in their required specialization. In this concern, this paper addresses the problem of faculty allotment to the various subjects so as to provide customers with quality engineers developed for their requirement.

The concept of lean is to reduce defects and unnecessary physical wastages. It is defines as (Capital, 2004) use of equipment and manufacturing space more efficiently and have the ability to produce a more flexible range of products with minimum changeover costs and changeover time. The index to indicate the knowledge waste is developed by applying the concept of minimization of waste, one of the themes of lean principles. A mathematical model is formulated with the objective of minimum knowledge waste subjected to practical constraints such as maximum number of subjects for a faculty, number of students in a batch and so on. The formulation indicates that the problem belongs to zero-one integer programming problem, which is NP hard. Besides, the model discussed in this paper, possible approaches to solve the above problem are discussed.

## 2.0 PROBLEM DESCRIPTION

### 2.1 Model

The educational system considered in this study is that of the mechanical engineering curriculum. The curriculum has a span of four years with two semesters in each year. Students have to undergo fundamental and core subjects of mechanical discipline in the first three years and elective subjects in any one of the specializations. Table 1 and Table 2 show the details of the subjects of study proposed for mechanical engineering curriculum that is witnessed to produce engineers with specific specialization.

*Table 1: Proposed Core Subjects for ME (Semester - 1 to 6)*

| Semester 's' / Subject 'i' | 1 | 2 | 3 |
|---|---|---|---|
| 1 | English | Mathematics-I | Mathematics-II |
| 2 | Physics | Electrical Engineering | Thermodynamics |
| 3 | Chemistry | C and Data Structures | Mechanics of Dynamics |
| 4 | Mechanical Engineering | Material Science | Mechanics of Solids |
| 5 | Civil Engineering | Electronic Devices and Circuits | Electronics and Microprocessors |
| 6 | Engineering Drawing | Mechanics of Statics | Machine Drawing-I |
| 7 | Physics Lab | C Programming Lab | Strength of Materials Lab |
| 8 | Chemistry Lab | Electrical Engineering Lab | Electrical Machines Lab |
| | 4 | 5 | 6 |
| 1 | Mathematics-III | Engineering Economics & Analysis | Computer Aided Manufacturing |
| 2 | Thermal Engineering-I | Thermal Engineering-II | Gas Dynamics |
| 3 | Mechanics of Machines-I | Mechanics of Machines-II | Design of Machine Elements-II |
| 4 | Manufacturing Processes-I | Manufacturing Processes-II | Metrology |
| 5 | Applied Metallurgy | Design of Machine Elements-I | Foundry Technology |
| 6 | Machine Drawing-II | Mechanical Measurements | Control Systems |
| 7 | Thermal Engineering Lab | Metallurgy Lab | Image Processing Lab |
| 8 | Workshop Practice-I | Workshop Practice-II | CAD & Drafting Lab |

*Table 2: Proposed Electives for ME (Semester - 7 & 8)*

| Specialization 'd' / Semester 's' | Design (1) | Thermal (2) |
|---|---|---|
| $S_7$ | Finite Element Methods<br>System Simulation<br>Vibration Engineering<br>Design for Manufacture<br>Computer Aided Design<br>Gear design | Compressors & Blowers<br>Air Conditioning<br>Cryogenics<br>Heat and Mass Transfer<br>Internal Combustion Engines<br>Nuclear Power Engineering |
| $S_8$ | Computational Methods<br>Geometric Modeling<br>Fracture mechanics<br>Product design<br>Project & Viva-Voce | Computational Fluid Flow<br>Power Plant Engineering<br>Automobile Engineering<br>Pollution Control<br>Project & Viva-Voce |
| | Production (3) | Industrial Engineering (4) |
| $S_7$ | Welding Technology<br>Materials Technology<br>Metal Forming Processes<br>Theory of Metal Cutting<br>Industrial Robotics<br>Production Planning | Operations Research<br>Financial Management<br>Work System Engineering<br>Human Resource Management.<br>Personnel Management<br>Entrepreneurship Development |

| | | |
|---|---|---|
| $S_8$ | Plant Layout & Material Handling<br>Non-Traditional Machining<br>Machine Tool Design<br>Quality Assurance<br>Project & Viva-Voce | Marketing Management<br>Operations Management<br>Supply Chain Management<br>Enterprise Resource Planning<br>Project & Viva-Voce |

A specific Number of Faculty (NF) are available in the department. Experience and specializations vary with faculty. They share the teaching load uniformly. It is assumed here as: each faculty has to handle at least "$NS_{min}$" number of theory subjects and at the maximum of "$NS_{max}$" number of theory subjects in any semester and the load is balanced with practical subjects. Splitting of subjects to faculty is not allowed. Industrial experience of faculty, faculty involvement in consultancy, lab development, and research work is not considered, when calculating the experience. The preference of the faculty to handle a particular subject is not considered during allocation. The same faculty can be allotted to more than one subject of a particular semester. For exa mple, core & elective subjects for semester 7 or 8. Table 3 provides a typical faculty data considered in this work.

*Table 3: Faculty Database*

| S.No. | Faculty | Specialization | Subjects Handled | Experience |
|---|---|---|---|---|
| 1. | $F_1$ | Design | Geometric Modeling, Finite Element Methods, Gas Dynamics | 12 Years |
| 2. | $F_2$ | Thermal | Heat and Mass Transfer, Thermodynamics, Mechanics of Solids | 3 Years |
| 3. | $F_3$ | Production | Manufacturing Processes, Foundry Technology, Applied Metallurgy, Operations Research | 7 Years |
| 4. | $F_4$ | Thermal | Thermodynamics, Cryogenics, Gas Dynamics, Heat and Mass Transfer, Engineering Economics & Analysis | 18 Years |
| 5. | $F_5$ | Industrial Engineering | Engineering Economics & Analysis, Supply chain management, Finite Element Methods | 3 Years |
| 6. | $F_6$ | Design | Mechanics of Solids, Geometric Modeling, Fracture Mechanics, Welding Technology | 10 Years |
| 7. | $F_7$ | Production | Plant Layout & Material Handling | 1 Year |
| 8. | $F_8$ | Thermal | Air Conditioning, Gas Dynamics, Applied Metallurgy | 7 Years |
| 9. | $F_9$ | Industrial Engineering | Operations Research, Engineering Econom ic & Analysis, Marketing Management, Thermodynamics | 14 Years |
| 10. | $F_{10}$ | Industrial Engineering | Marketing Management, Operations Research, Human Resource Management, Cryogenics | 5 Years |
| 11. | $F_{11}$ | Design | Geometric Modeling, Operations Research, Mechanics of Solids | 12 Years |
| 12. | $F_{12}$ | Production | Plant Layout & Material Handling Foundry Technology, Applied Metallurgy | 7 Years |
| 13. | $F_{13}$ | Thermal | Thermodynamics, Cryogenics, Heat and Mass Transfer, Finite Element Methods, Supply Chain Management | 19 Years |
| 14. | $F_{14}$ | Design | Fracture Mechanics, Mechanics of solids Resource | 3 Years |
| 15. | $F_{15}$ | Industrial Engineering | Marketing Management, Operations Research, Supply Chain Management, Cryogenics | 4 Years |
| 16. | $F_{16}$ | Production | Foundry Technology, Manufacturing Processes | 2 Years |

### 2.2 Objective

The objective is to provide maximum knowledge gain to the students. The allocation of the faculty to the subjects is done matching the characteristic features of the faculty as outlined in Table 3. It is expected that proper match leads to maximum knowledge gain to the student. In this context, the objective of this paper is to allocate subjects to faculty such that Students Knowledge Gain (SKG) that the students could obtain is maximum.

## 3.0 LEAN CONCEPT MODEL

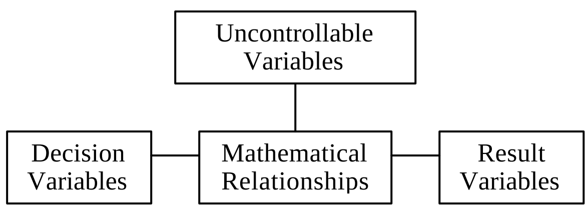


*Figure 2 Lean Concept Model*

System - Educational Institutions
Decision Variable - Which Faculty is assigned to which subject
Result Variable - Maximize SKG / Minimize the total knowledge wastage
Uncontrollable Variable - Students interest to take specializations are changed in every year. (Change in Demand)
Environment - Allowing different students to take different specializations.

The evaluation parameter Faculty Knowledge Wastage Index (FKWI) is derived using the faculty data. Table 4 shows the guidelines proposed for evolving KWI, which is assumed as dependent on three criteria: Specialization, experience and previous experience in the subject.

*Table 4: Guidelines for FKWI*

| S. No. | Specializ -ation | Whether already Handled the Subject | Total Years of Experience | FKWI (Points) |
|---|---|---|---|---|
| 1. | YES | YES | 6 + Years | 0 |
| 2. | YES | YES | 0 to 6 Years | 1 |
| 3. | YES | NO | 6 + Years | 2 |
| 4. | YES | NO | 0 to 6 Years | 3 |
| 5. | NO | YES | 6 + Years | 4 |
| 6. | NO | YES | 0 to 6 Years | 5 |
| 7. | NO | NO | 6 + Years | 6 |
| 8. | NO | NO | 0 to 6 Years | 7 |

## 4.0 MATHEMATICAL MODEL

The objective of this model is to allocate subjects to faculty in ODD/EVEN semester, so as to maximize SKG. Applying the concept of lean, the objective is changed to minimization of Total Knowledge Wastage (TKW), which is the reverse function of SKG. Hence, the objective function for ODD semester becomes:

Minimize TKW =

$$\sum_{s=1,3,5}[\sum_{i=1}^{NS_s}\sum_{j=1}^{NF} M_{sij} \times X_{sij}] + \sum_{d=1}^{4}[\sum_{i=1}^{NS_7}\sum_{j=1}^{NF} M_{dij} \times X_{dij}]$$
(1)

The constraints to the problem are,

1. Minimum number of subjects allocated to a faculty

$$\sum_{s=1,3,5}\sum_{i=1}^{NS_s} X_{sij} + \sum_{d=1}^{4}\sum_{i=1}^{NS_7} X_{dij} \geq NS_{min} \text{ , for all j}$$
(2)

2. Maximum number of subjects allocated to a faculty

$$\sum_{s=1,3,5}\sum_{i=1}^{NS_s} X_{sij} + \sum_{d=1}^{4}\sum_{i=1}^{NS_7} X_{dij} \leq NS_{max} \text{ , for all j}$$
(3)

3. Each core subject of semester 1, 3, 5 should be allotted to a faculty

$$\sum_{j=1}^{NF} X_{sij} = 1 \text{ , for s=1, 3, 5 and i=1 to } NS_s$$
(4)

4. Each elective subject of 7th semester should be allotted to a faculty

$$\sum_{j=1}^{NF} X_{dij} = 1 \text{ , for all d and i=1 to } NS_7$$
(5)

where,

d - Discipline Identifier
i - Subject Identifier
j - Faculty Identifier
$M_{dij}$ - FKWI for the ith subject of 7th semester in dth discipline to jth faculty
$M_{sij}$ - FKWI for the ith subject of sth semester to jth faculty
$NS_{max}$ - Maximum number of theory subjects to be handled by a faculty
$NS_{min}$ - Minimumnumber of theory subjects to be handled by a faculty
$NS_s$ - Number of theory subjects in semester's' (1, 2, 3 . . .)
$Ns_7$ - Number of theory subjects in 7th Semester
s - Semester Identifier. (s=1, 3, 5 for ODD Semester & s=2, 4, 6 for EVEN Semester)
$X_{sij}/X_{dij}$ - Binary Variable ($X_{sij}/X_{dij}$ = 1, if allocated or $X_{sij}/X_{dij}$ = 0, if not allocated)

Similarly, the model will be modified to calculate the TKW in EVEN semester.

## 5.0 PROPOSED METHODOLOGY

**Step I:** Design of Curriculum. (Table 1 & Table 2)
**Step II:** Creation of faculty database. (Table 3)
**Step III:** Derivation of FKWI subjectwise. (Table 5)

The KWI ($M_{sij}$) for the ith subject of semester's' to faculty j is derived using the Table 5.

*Table 5: Knowledge Wastage Index for NF faculties with $NS_s$ subjects*

| Semester 's' | j \ i | | 1 | 2 | | j | | NF |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | | | | | | |
| | 2 | | | | | | | |
| | | | | | | | | |
| | i | | | | | | | |
| | | | | | | | | |
| | $NS_1$ | | | | | | | |
| 3 | 1 | | | | | | | |
| | 2 | | | | | | | |
| | | | | | | | | |
| | i | | | | | | | |
| | | | | | | | | |
| | $NS_3$ | | | | | | | |
| 5 | 1 | | | | | | | |
| | 2 | | | | | | | |
| | | | | | | | | |
| | i | | | | | | | |
| | | | | | | | | |
| | $NS_5$ | | | | | | | |
| 7 | d=1 | 1 | | | | | | |
| | | 2 | | | | | | |
| | | | | | | | | |
| | | 6 | | | | | | |
| | d=2 | 1 | | | | | | |
| | | 2 | | | | | | |
| | | | | | | | | |
| | | 6 | | | | | | |
| | | | | | | | | |
| | d=4 | 1 | | | | | | |
| | | 2 | | | | | | |
| | | | | | | | | |
| | | 6 | | | | | | |

**Step IV:** Allocation of faculty by solving mathematical model.

## 6.0 SOLUTION METHODOLOGY

The problem belongs to zero-one IPP. Branch-Bound technique is generally addressed for such problems. However, it is time consuming process and still lacks to provide optimal solution. Meta-heuristic, find much attention nowadays for problems of this nature (Salcedo-Sanz et al, 2006). Figure 3 shows the different meta-heuristic approaches. In these considerations, the meta-heuristic are proposed to solve the above problem.

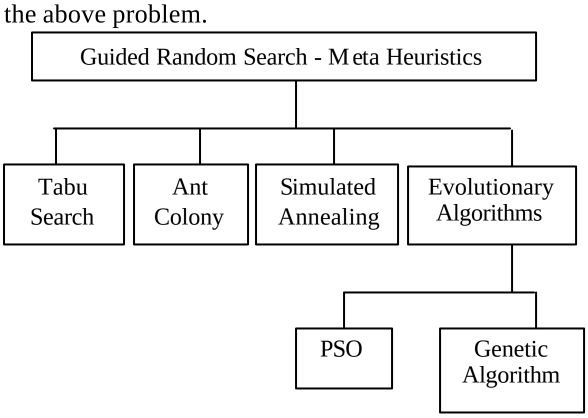


*Figure 3: Meta-Heuristic Search Techniques*

## 7.0 CONCLUSION

The Knowledge Management is not just another expensive fad in the educational arena. The knowledge is a new paradigm for the way of work. Now premier institutions have found a way to use modern technology to perform true knowledge management. The leveraging of an entire institution's intellectual resources is a powerful concept that can become a reality. The key issue in knowledge management in educational institution is faculty-subject allocation problem which can be solved by using the lean concept. The faculty-subject allocation problem is solved using the meta-heuristic approach and a decision support system can be developed.

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