Establishing an Engineering Technology Education (ETE) Framework at S.J. College of Engineering

[a]Dr. A.N. Santhosh Kumar, [b]Dr. K. Chadreshekara
[a]Professor, Department of Mechanical Engineering
Sri Jayachamarajendra College of Engineering
Mysore-570 006 Karnataka State, India
Email: dr_ansk@rediffmail.com
[b]Professor,Department of Mechanical Engineering
Sri Jayachamarajendra College of Engineering
Mysore-570 006 Karnataka State, India
Email: dr.chandrusjce@yahoo.com

Dr. B. G. Sangameshwara
Principal
Sri Jayachamarajendra College of Engineering, Mysore.
Email: bgsangam@yahoo.com

Abstract

The problems faced by the society such as peace and conflict, human rights, energy and other depleting resources, environmental pollution, excessive inflation and recession have their roots in various sources. One is related to Engineering Technology Education (ETE). The need for redesigning the Engineering Technology Education System (ETES) is established in the first section. The second section explains in detail the present scenario of ETE. In the third section a brief review of different approaches for problem solving is presented. Based on this, a ten step frame work for the analysis of the ETES is proposed. Fourth section illustrates the methodology used for the determination of value or worth of institution and discussion about the results of analysis. Fifth section gives the concluding remarks.

I THE NEED

“All education springs from images of the future and all education creates images of the future. Thus all education whether so intended or not, is a preparation for the future. Unless we understand the future for which we are preparing us may do tragic damage to those we teach (l)".

If we intend to impart good ETE to the students in the institutes, what sort of preparation we need and in what perspective the ETE should be viewed? From where we should get explicit support for such preparation? What pedagogical traditions we must build into the ETES? This paper answers some of these questions from the perspective of Educational Research Project taken-up in our institution.

We are now caught in a web of global inter-relationships in which our actions and those of others seriously affect our society and environment faraway in space and time from our own [2], More often ETE in any country is dealt at local and national level. But the nature of ETE for the future can not be thoroughly understood unless set in a global context. Many people have stressed the crucial role to be played by ETE in the contemporary issues such as peace and conflict, human rights, energy and other depleting resources, environmental pollution, excessive inflation and recession. These issues have human condition and its improvement as a common factor [3]. There is much evidence that the use of ETE in tackling the. Contemporary issues, which give rise to societal problems, have often led to much less desired results [4]. Strategies have been developed to remedy problems such as policy formulation, syllabus revision, faculty development, student’s development, industry institution liaison, entrepreneur development etc. Often the strategies or solutions at these levels exacerbates the original problem and make the implementation more difficult. Many have concluded that something is seriously wrong with ETE. Others would not go this far but would argue that tackling the problems of ETE at symptoms level is no longer adequate. Looking into the future, the challenges that face society calls for dramatic change in the ETES's structure and form [5], [6]. In the next decade our world will have about ten billion people to manage and feed. We will have to get more food from what farmed land we have. This would call for innovations in the existing agricultural methods. This would also stress the need for a good water resource management and fertilizers which could result in higher yields. Increased energy will be required to build irrigation agriculture and to make artificial fertilizers. Coal and oil would be harder to fetch and amount of investment per unit of energy harnessing will continually increase. There would be also change in the level of tolerance of the society towards whatever is bad. This is to be expected because, in the coming decades, the world will be changing from humanity of illiterates to humanity of literates. Demonstration of western middle class levels of town planning, housing, transportation, health care, education and other amenities through mass media of communication to the people all over the world is going to change the needs and expectations of the society. Industrialization of countries could act as a possible medium by which the needs of the society could be satisfied and decrease the inequality. But, then, this calls for preparing our technical man power for the future. Until many of the world's governments understand that a large-scale engineering knowledge acquiring process is built into the ETES, they always tend to produce mediocre technical man power. Lack of understanding of structure and form (morphology) of ETES often leads us to the wrong conclusion regarding problem solution. Our ETES has to be viewed as a system which should be forward- looking, which anticipates the hardships and hopes associated with ever changing technologies, which identify the schemes of global interdependence and hanging economic realities.

II THE SITUATION

The present ETES has several deficiencies. The system lacks flexibility, dynamism, credibility, reliability, compatibility, sustainability, etc. The uniform policy adopted in admitting students to the institutions has resulted in a worry amongst the Engineering Technology Educators. Faculties of ETE usually feel that they do not carry the same social status that a practicing engineer carries. The working conditions of the teaching fraternity need to be improved. There are no built-in mechanisms into the system by which brighter engineers could pursue teaching profession without any inhibition, upgrade his knowledge continuously, use novel and innovative methods of educational technology, be aware of global issues, principles and practices of ETE, exercise critical thinking skills and creative imagination more effectively.

Industries have their own reservations in participating actively in desirable changes in ETE. Quite a few large public and private sectors do not believe in the quality of technical man power generated by ETES and consequently have their own training programmes. There is much evidence that the infrastructure planning in institutions is generally inadequate. We have an incompatible, complex and confusing administrative set up both at macro and micro level. There are no just and sustainable policies in affiliation and accreditation of engineering institutes. Integration of macro (Government) and micro level (Institutions, Industries and Societal sectors) in the ETE is still to be achieved.

We also have a very rigid syllabus framing process. Rigidity is also prevailing in the examination and qualifying process of ETES. The examination system does not have a desirable procedure by which the students attributes such as developing a more future-oriented perspective both on their own lives and events of the wider world; exercising critical thinking skills and creative imagination more effectively, participating in more thoughtful and informed decision making in the present setup, engaging in the active and responsible citizenship, both in the local, national and global community and on behalf of present and future generation. Our system is not adequately promoting the spiritual, moral, cultural, mental and physical development of the students, not preparing them for the opportunities, responsibilities, experiences of adult life and paucity of financial resources for these is very high.

III THE VISION

In order to accomplish an effective, just and sustainable ETE for the future, it would appear that we need a way to deal successfully with the complex and interrelated issues of ETE [7]. We need a way to deal with issues in which value elements and structural elements of ETE-are given full consideration. Further, a set of guidelines is required for analysts to allow full and effective interaction among stake holders in this complex system such as political system, institutions, user system including decision and policy makers, individuals or groups responsible for implementation of comprehensive approaches to public welfare programmes.

Warren Kinston and Jimmy Algie [3] are of the opinion that if individuals have to have control over their own actions and to facilitate this, they require a frame work which encompasses the possible distinctive approaches to decisive action from their own practical stand point. The systemic approach seems to be appropriate for our work. Gerald Nadler [4] in his paper has identified that systems approach is an inductive process and encourages analyzing for as many "facts" as possible. Basic survey of systems engineering methodology has been elaborately done by Arthur D Hall [5]. He is of the opinion that the systems engineering methodology when understood in its entirety is considered as a process which portrays the essence of the systems approach. J. Douglas Hill and John N War Field [6] in their paper have discussed in detail the key products that result from the problem definition, value system design and system synthesis steps and explain how these could be interrelated through interaction matrices. Based on the literature survey we have identified a ten step framework for the analysis of ETE for the future as shown in plate 1.

Plate 1: Ten step frame work for the analysis of ETE.

1) Analysis of the need.
2) Problem structuring.
3) Identification of morphology of ETE.
4) Hierarchical multi-objective value system design.
5) System triggers synthesis.
6) Progressive modeling.
7) Total situation control.
8) System fit between outcome and scenario.
9) Action Planning.
10) Testing and Implementation.

This paper intends to consider steps 9 &10 in detail. However, Step 1 through 8 have been successfully carried out and the basic structure and form of ETE, which is seemingly quite adequate for the development is given in figure-1

INFORMATION FROM POLITICAL, SOCIAL & LEGAL ENVIRONMENT

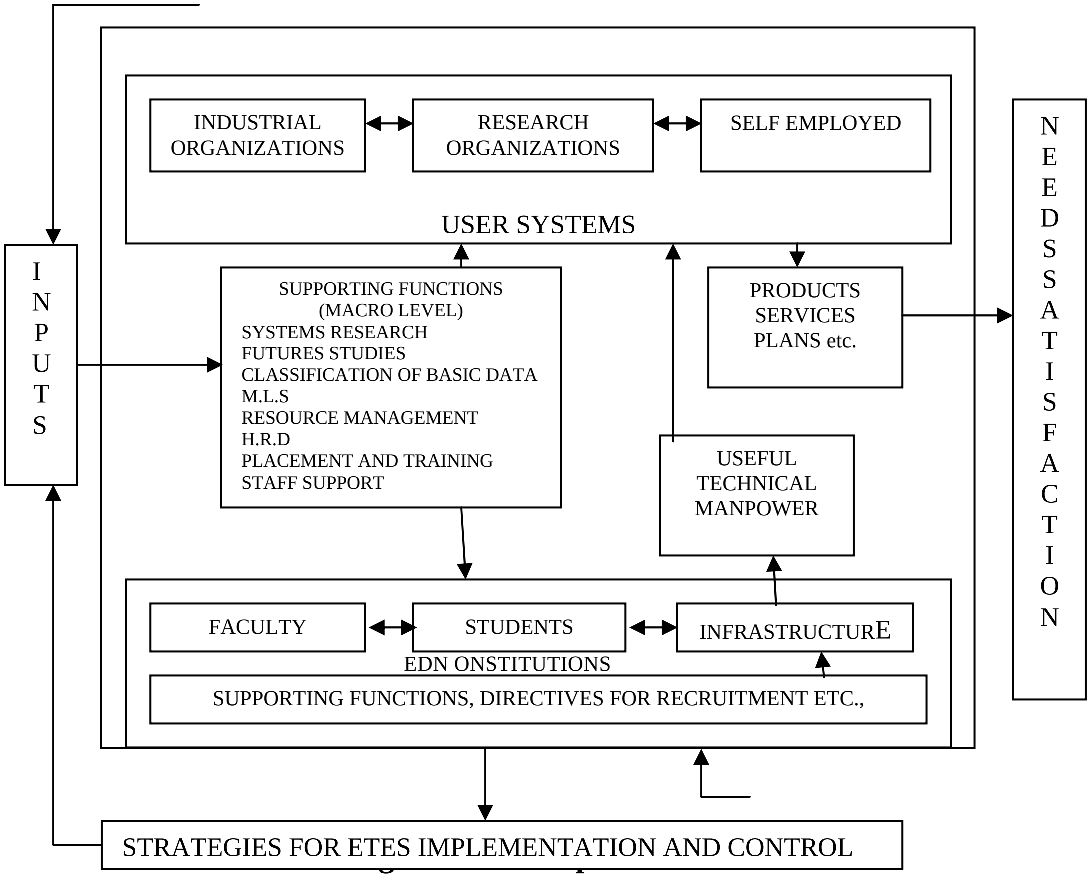


Figure-1

L.Robin Keller and Joanna L Ho [7] are of the opinion that a well structured problem would open ways and means for generating options for the issues under study. This has helped us in conceiving a title for the problem, that is "To design strategies and means of effectively and optimally utilizing technology, policies, resources, information about societal needs by establishing and analyzing interrelationship, compatibility accountability, adaptability and sensitivity amongst the solution variables such as faculty development, students development, infrastructure development, industrial organization’s participation so that the society will have a better world to live in future". The relevant elements of the problem have been identified as shown in Plate 2.

Plate- 2: Relevant elements of the problem

1) Integrated development of faculty (IDF)
2) Overall development of students. (ODS)
3) Effective infrastructural development (EID)
4) Developing effective industry-institution liaison. (EIL)
5) Bringing co-ordination amongst policy makers, technology growth, user systems, educational system, concerns of public welfare needs and resources. (PTU)

Also some selected subjective elements in the ETE have been identified as shown in Plate 3.

Plate-3: Some subjective elements in the ETE

1) Policy makers and policies.
2) Technology forecasting
3) Technology Utilization
4) Expectations of user systems about the Products of ETE.
5) Pedagogy of ETE.
6) Expectations of the society.
7) Political-Social-Economic and Legal Environment

We are of the opinion that the initially chosen structure and form of ETE need not be entirely authentic but reasonably adequate to permit the systems approach methodology to be used, developed and structured an initial form that is seemingly quite adequate for development is also represented in Figure 1. It describes the interactions amongst relevant elements of the problem. The overall system is depicted as a box with primary inputs and outputs. The primary inputs identified are the Policies, Technology forecasting, Resources (Macro level), Needs and Public welfare concerns of society. Health, Education, Culture and employment. Physical environment, community life and social mobility are identified as other environmental factors. One must note here that the inputs are greatly influenced by the political-social-economic-legal environment. Output of the system is identified as the societal needs satisfaction.

One important characteristic of the initially chosen structure and form is the feed back and feed forward nature of the solution variables chosen such as Industrial organization, Service institutions, self employed, faculty, students and infrastructure. One should also not neglect the role played by supporting functions such as management information system, examination system etc., at macro level and recruitment of faculty, educational technology, subsidies, grants etc, at micro level. The advantages of horizontal and vertical integration of the subsystems are kept in mind. Thus the basic relationship between the subsystems is established. It is expected that the competency of faculty or the development of faculty is greatly influenced by the development of students and vice-versa. Also development of faculty and students is affected by the infrastructure planning. Strategies for ETE implementation and control are considered to be the other two environmental factors which are affected by the societal needs satisfaction level. Closed loop nature of the system identifies the cyclic nature of the whole process of Engineering Technology Education [12]

Several decisions have to be taken and numbers of criteria have to be identified with regards to the elements of the problems chosen (projects). Decisions have to be taken with regards to the consistency and the scope of the projects with the objectives and policies of ETE, economics of the projects, risks associated with the projects, public welfare that would result from the pursuit of each alternative project and the time dimension involved in each project. In doing this, major evaluation factors such as accountability of strategies are proposed. For each project, sensitivity amongst the various elements of the projects, adaptability of the system to ever changing environmental conditions and the reliability of the system should be taken into consideration. Several tools, techniques and methods have been proposed which could aid the analyst in taking decisions in complex systems [8]. At the end of this phase, important criteria which will identify the acceptability or the degree of excellence of each project could be thoroughly understood.

In our Institution it is intended to make trade off studies and detailing of functional sequences in order to describe the total scenario of ETE. By this, strategies, activities, accountability, adaptability etc, could become very clear. We are of the opinion that the Multi-Objective Optimization Theory (MOOT) [9] could be used in eliminating inferior alternatives of projects. An experimental method suggested by Fumiko Seo and Masatoshi Sakawa [10, 11] wherein the alternatives are evaluated based on sensitivity analysis. Multi Attribute Utility Function (MUF) could also be considered for setting up a multi criteria optimization problem. By this the harmony of strategies (activities proposed), would become very transparent. For example, balancing the degree of excellence of faculty against cost of beneficiating, the degree of excellence of the students (identified by a measurement system) with, faculty development, user system participation with infrastructure development, balancing of expectations of the society and resources available with political-social-technological-economic [13] harmony required will all become very clear. An analytical procedure could be identified to build in the nature of compromising amongst various alternatives of the projects. The first factor to be considered in action planning is the risk analysis. The evaluation of these risks is predominantly dependent upon expert opinion and subjective judgments. The functional performance parameters identified for each project could be broken down to lower levels and risks associated with each of these could be identified. The second factor to be considered in action planning is the worth assessment of discrete alternatives of each project. This, could be done by defining the worth criteria and developing hierarchical structure of worth assessment criteria. Performance measures of various activities suggested for each project must also be identified. Further a single overall index of worth could be identified for each project and these could be used to identify the worth of the whole ETE.

IV THE METHODOLOGY

There are various important driving forces for defining the process of testing and implementation of the activities/strategies, proposed for the ETE. Basic developmental goals of the regions pertaining to population growth control, employment potential, degree of industrialization, social political-economic environment etc., would be few amongst the driving forces. These goals are not in themselves to produce a set of projected activities for ETE but calls for thorough analysis of the system itself. In this section the methodology used for the identification of value or worth is described. The effectiveness factors considered are given in Plate 4.

Plate 4: Effectiveness Factors

1. Integrated development of faculty (IDF), [14, 17]

The indicators are:

a) Motivation by means of promotions and rewards for acquiring higher qualification, papers publication and involving in research activities by bringing externally funded projects.
b) Providing conducive working environment, by giving opportunities for overall growth of the faculty like access to laboratories off the office hours, some place to relax like Yoga centre, indoor games and cafeteria, providing independence to buy books and subscribe to Journals of his choice etc.,
c) Providing opportunities for Training, Industrial visits and creating opportunities for consultancy work etc.,

2. Overall development of students (ODS)

The indicators are:

a) providing conducive learning environment for curricular activities like organizing technical talks by experts in the related fields, seminars, symposiums, workshops, industrial visits etc.,
b) providing conducive environment for co-curricular and extra curricular activities like organizing cultural festivals, sports events, quizzes, debates etc.,
c) Providing good platform for placements by organizing mock Group Discussions, Mock Interviews, Mock Tests and exhibition of worth of the institution in terms of infrastructure and the quality of the graduates to the recruiters.

3. Effective infrastructural development (EID)

The indicators are:

a) Providing state of the art class rooms like making them Electronic Multimedia classrooms with all modern teaching-learning aids.
b) Acquiring state of the art lab equipments and continually upgrade and maintain the existing equipments by training the lab technicians according to the growth of technology.
c) Providing good hostels and sports facilities and other amenities like cafeteria, reading rooms, Multi gym and maintaining good landscape on the campus.

4. Developing effective industry- institution liaison (EIL), [16]

The indicators are:

a) Providing on the job training for students by deputing them to the industries of their choice.
b) Involving industry in the formulation of the curriculum and participation of them by means of providing projects to the students and faculty.
c) arranging special lectures by industry personnel for students and faculty

5. Bringing coordination amongst policy makers technological growth, user system (PTU)

The indicators are:

a) Accreditation by national board of accreditation (NBA)
b) Making society realize the importance of engineering and technological growth by organizing community services, technical talks etc.

c) Making industries realize their active participation in pedagogy of institutions and society out reach.

The above indicators chosen are the indicators considered by National Bureau of Accreditation (NBA) in arriving at the points for engineering colleges in order to asses the worth of the institution in terms of grades. S.J College of Engineering has been accredited thrice in the past ten years. This paper is the outcome of Educational Research taken up by us and being continued from past ten years. The outcome of the research and its presentation has elevated our college to Autonomous status. The model which has been envisaged to test the proposal is discussed below and the results are tabulated in tables 1, 2 and 3.

Multi-Functional Criteria Technique (MFCT) is used for the determination of worth or value of integrated development of our institution. For Integrated Development of Faculty (IDF), promotions, rewards, number of PhD’s, training of faculty; papers published by the faculty are considered to be indicators of development. These numbers are identified in percentage for the indicators. Then the average of these percentages are calculated and tabulated. This has been done for three year periods starting from the year 1995 to 2006. A weight of 0.3 is assigned for IDF. For Overall Development of Students (ODS), number of journals, text books, learning resources, teaching aids, special lectures arranged, cultural festivals, sports events, mock interviews and group discussions arranged by the college are considered as indicators of value addition. A weight of 0.3 is assigned for (ODS). For Effective Infrastructural Development (EID), the amount of money spent in possessing quality and state of the art infrastructure is considered as the main indicator. A weight of 0.15 is assigned to (EID). This does hot mean that money is less important in value addition to the institution but IDF and ODS have relatively more important than (EID). For developing effective industry institution liaison, number of industrial visits, number of times the industries participated in curriculum revision, number of times the persons from industry gave special lectures is considered to be the main indicators. A weight of 0.15 is assigned for (EIL). For bringing coordination amongst policy makers, Technological growth, user system (PTU), number of times the institutions has gone through the accreditation by NBA, arrangements of exhibition, number of tribal development programmes, and community services the institution has conducted are considered as indicators. A weight of 0.10 is assigned for PTU. Using these numbers a morphological table has been constructed on a scale of 0 to 10 [table-1]. One must note that all the effectiveness parameters chosen have a positive contribution to the worth or value of the institution.

The minimum value of the factor is assigned zero preference number and maximum value of factor is assigned a preference number of 9. From the concept of utility, for each unit increase in the value of the parameters, the value increase will not be linear but logarithmic. At higher values of factors, the contribution of the factors would be only nominal. The relationship between contributions of the values of factors towards value of the institution is given by

$$P = A \operatorname{Log}_{10} \frac{\text{Max Value of the factor}}{\text{Minimum value of the factor}} \qquad \text{Equation - 1}$$

Minimum preference number 0 is assigned to the value of factors for the period 1995-1997 max preference number 9 is assigned for the values for the period 2005-2007. The preference numbers for periods 1999-2001 and 2002-2004 are calculated using equation 1& 2.

$$P = A \operatorname{Log}_{10} \frac{\text{Value of factor to which pref. number 9 is assigned}}{\text{Value of factor to which 0 is assigned}} \qquad \text{Equation - 2}$$

For Example: for IDF, for the year 1998-2000, parameter ‘A’ is calculated as follows (for calculation of A, P is arbitrarily assigned preference number 9. Therefore,

$$9 = A \operatorname{Log}_{10} \frac{99}{19} \quad = A\,1.65$$

Now, preference number for the year 1998-2000 is:

$$P = A \operatorname{Log}_{10} \frac{41}{19} = 4.19$$

Similarly the intermediate values of preference number are calculated for all effectiveness factors and tabulated [Table-2]. These preference numbers are multiplied by the corresponding weights of the factors and added to give the comprehensive indices with respect to each period. This is shown in Table-3

V CONCLUDING REMARKS

This paper has considered the value system design for our institution. 5 important factors are considered for the determination of increase in value or worth of the institution for a period of 10 years. The activities, strategies to reduce faculty inefficiency resources non availability, discrepancies in student input, non participation of user system in ETE etc., and to modify infrastructural plans supporting functions were started in the year 1995. One must also note that, these strategies must be compatible with present trends in ETE but some strategies might not be. Obviously this would result in identifying a process for selecting appropriate strategies for the factors considered. Consequently this would call for not only analytical models, but specific sets of activities (19) needed to impart effective ETE which considers ever changing needs (20) of the society and also considers social and institutional barriers.

The graph is clearly illustrating that the nonlinear variation of value addition. Also it is illustrating the law of diminishing returns. This says, beyond certain stage, any increase in the contribution of the effectiveness factors, the value added is not substantial. Hence, it can be concluded that, whatever effort the institution has made towards the development of all factors considered, is adequate. Beyond these efforts the value addition to the institution is not substantial but only nominal.

Table 1- Morphological Table

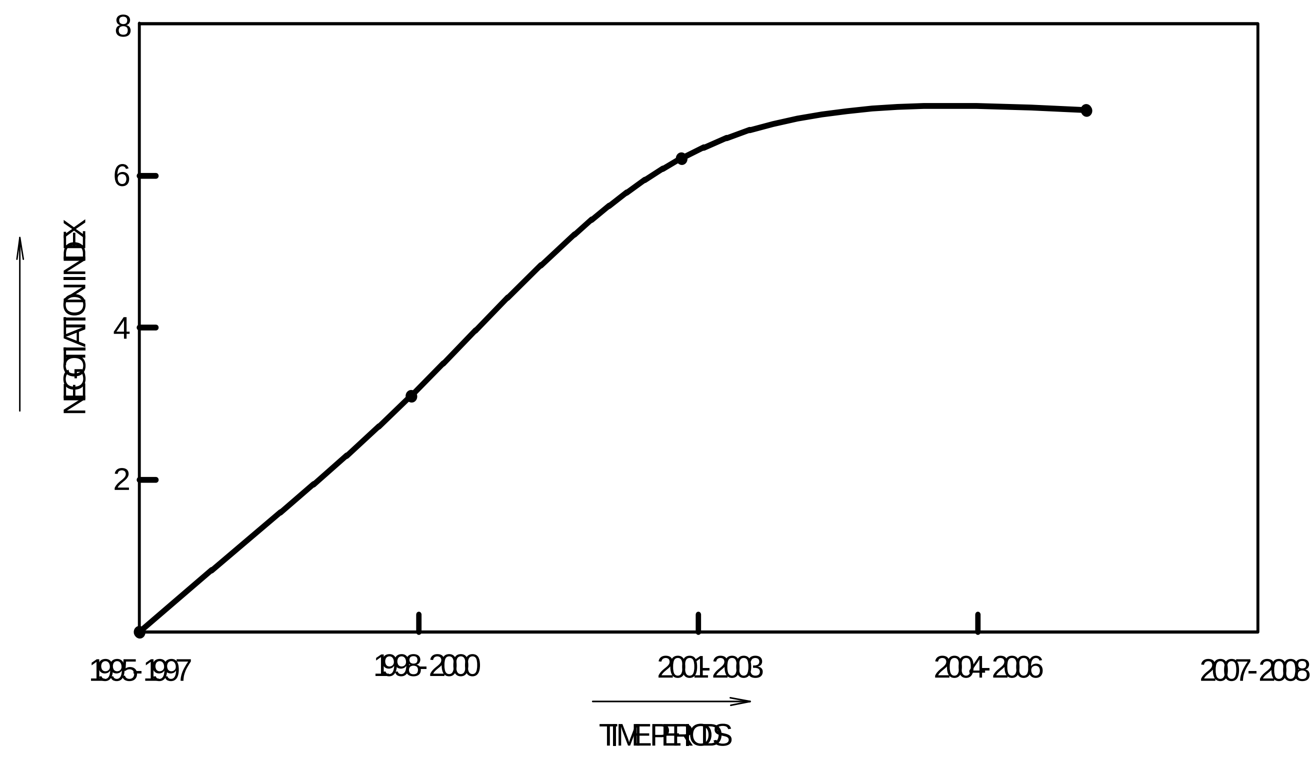
Effectiveness factor	1995-97 (Average Percentage)	1998-2000 (Average Percentage)	2001-03 (Average Percentage)	2004-06 (Average Percentage)
IDF	19	41	78	99
ODS	25	38	74.22	57
EIF	20	40	74.8	85
EIL	25	34	60	70
PTU	20	32	75	85

Table 2- Preference Number Table

Effectiveness factor	1995-97	1998-2000	2001-03	2004-06
IDF	0	4.19	7.69	9
ODS	0	3.47	9	6.81
EIF	0	4.31	8.25	9
EIL	0	2.68	7.65	9
PTU	0	2.92	8.22	9

Table 3-Weighted Preference Number Table

Effectiveness factor	1995-97	1998-2000	2001-03	2004-06	weight
DF	0	1.25	2.3	2.7	0.3
ODS	0	1.041	2.7	2.0	0.3
EIF	0	0.64	1.23	1.35	0.15
EIL	0	0.402	1.14	1.35	0.15
PTU	0	0.29	0.822	0.9	0.1
Index for the Year	0	3.623	8.192	8.3	



Graph - 1

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