QUALITY IN ENGINEERING EDUCATION

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SYNOPSIS

The diploma & degree engineering educational system is the important component of the total eucational system. To-day's society is techno-social in nature & even this system is dynamic in nature.

To build up & maintain this system requires qualitatively educated & trained people who can proactively act to maintain quality of technical education.

The policy - makers & designers of the Engineering Education System must attend to the main question of improving quality of education.

The only way to maintain such quality is to professionalise the education personnel i.e. there must be a professional instructional designers, curriculum designers, institutional designers & state level educational systems designers.

1.0 Viewing Educational System As An Open System :

To-day's Engineering Educational System operates at national, state, institutional, departmental, subject teachers & individual students level. These systems not only have a distinct common pattern, but also are ordered in hierarchical relationship.

The ministry officials & the directorates of Technical Education, teachers & students must share a common "mental model" for viewing their own systems & its relationship with other systems at higher & lower levels.

2.0 What is "The Open System" Model :

Any Social System can be viewed as an "open system", which can be graphically presented by fig.1.

Such a system's existence is determined by the need of a clients/ customers; such a need determines the type of "services/product" (output) the system should provide; outputs are further categorized into "proposed output" & "actual outputs". The system needs "inputs" which it "converts" into "output". Inputs are categorized into "signal input" which is the raw material (physical, information or human) which is converted into outputs, and "Maintainance input" which is used to build infrastructure in which the actual transformation process takes place; the "maintainance input" comprises a)physical resources, b) human resources, c)information resources, d) energy resources, e)time resources, f) financial resources. The "conversion process" is subdivided into "structure" & "function" Structures are described in terms of roles, individuals teams, departments etc. and are assigned "counter roles" the other team with which they interact. Roles are further described in terms of "function" i.e. the expected behaviour of the structures that are carried out to ensure that the "conversion process takes place".

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Every system works in an "environment", which it tries to influence & is influenced by it. Environment is further categorized ito "general environment" & "task environment". Task environments are those individual, team or social systems whose policies & actions *directly* affect the subject systems, whereas those subsystems whose policies & actions indirectly affect the subject system are categorized as "general environment".

The "subject system" is seperated from the environment by a "boundry". The boundry consists of structure which is responsible for "filtering" inputs from the environment into the system so that only appropriate input enters the system in order that the pattern of the conversion process does not get disturbed & the system remains in a steady-state.

* The system maintains itself into a steady-state through the mechanism of "feedback". Feedback ensures that the "Management" of the system obtains information on the consequences of the systems functioning & takes decisions about future courses of action for either corrective actions or furthering systems objectives.

Briefly, the system has following structural components which are in a dynamic interaction with each other, so that the system provides products/ services appropriate to the customer's needs.

1) Customers, 2) Proposed output, actual output, 3) Input (Signal input & Maintenance input, 4) Conversion process (structure & function), 5) Environmental (task & general environment), 6) Boundry, 7) Interface, 8) Feedback 9) Management.

There is also the concept of "system dynamics" which states that every system tends to maintain itself in a steady state through following process. These processes are categorized into -

a) Externally oriented processes;

b) Internally oriented processes.

Externally oriented processes consist of : (a)Goal attainment & (b)Adaptation function. Goal attainment ensures that the system is oriented towards customers needs & provides products & services accordingly.

Adaptation ensures that the system adapts environment to facilitate goal attainment. This includes specifying output specification, regulating inputs & structuring "conversion process" appropriately.

Internally oriented processes are also of two types:- (a) integration, & (b) pattern maintenance.

Integration is the process of ensuring alignments of individuals, teams, depts. etc. toward goal attainment & adaptation.

Pattern maintenance is the process in which core pattern of behaviour of components of the systems are maintained to ensure that integration, adaptation & goal attainment actually takes place.

3.0 Need For Understanding "System Concepts" :

An attempt is made to present a "mental model" of General Open Systems concept. The first prerequisite for ensuring quality of engineering education is to understand this "model". Models are important because they guide the thinking process of the professional educators. They also drive home the point that no social system including the education systems is a simple system & to solve problems facing the educational systems, the professional educator must first learn how to *view* the systems in

terms of "open systems" paradigm. Having been able to describe one's own system in systems terms, only then one can *diagnose* the system, *design it* & *develop it* & *implement* it & *evaluate* it.

THUS THE FIRST STEP TOWARD IMPROVING QUALITY OF ENGINEERING EDUCATION IS TO UNDERSTAND IT IN THE "OPEN SYSTEMS" PERSPECTIVE.

4.0 Understanding Hierarchical Relationship Among Systems At Various Level :

Fig. 2 is the diagram which explains that any educational system exists at six levels -- viz.

1) Individual learner as a system;
   (built up of knowledge, abilities & attitudes),
2) Class-room based teaching /learning system;
   (acquisation of organized body of knowledge, abilities & attitude within the subject level)
3) Total Course Curriculum as a system; (acquisition of knowledge, abilities & attitudes through the vertical & horizontal organization of learning through various subjects comprising the whole curriculum).
4) Institute as a system;
   (providing a group of students opportunities to acquire competence in different areas of work at a single place both through formal & non-formal courses)
5) State level educational system;
   (Comprising integrated set of educational institutions, administrative & H.R.D. system geared to provide educational opportunities to state level population of aspiring students).

Fig.3 shows that all these systems are related hierarchically. It means that a student as an individual learning system is embeded in the classroom learning system, which in term is embeded in the next higher level system i.e. total curriculum system & so on. The consequence of understanding such a hierarchical relationship is that every professional educator knows that when he/she attempts to analyse system at any level, he/she has to consider the impact of the subsystem at a lower level & supra-system at a higher level. He/She knows that no educationl system can ever be improved until he/she attends to the impact of his/her decision to act in the systems below as well as the system at a higher level.

5.0 Understanding Eduational System At Every Level :

The next step for improving the quality of education is to understand the nature of "educational processes" at each level.

1) Individual Learner as a system (fig. 3)

This is graphically explained in Fig.3. Learner is an information processor who receives information input from the enviroment or internal sources (stored knowledge & experience) and process this input through its memory structures (Sensory Register, short term/working memory, long term memory) for understanding, storing new information through his/her covert & overt performances (cognitive, motor, affective & interactive skills).

He/she constantly sets himself/herself learning goals, adapts his learning process to attain the goal, maintains integration of his/her physical, psycological, moral components of his/her behaviour through basic behaviour

pattern of learning & doing in daily activities.

The Quality of learning is measured by

a) Quality of learners overt performance i.e. congnitive, motor, affective & interpersonal overt behaviour.

b) Quality of lerners covert performance i.e. Attention to stimuli perceptiveness, processing, unserstand storing of information in LTM, retrieving information from LTM.

c) Quality of Cognitive strategies to self-manage this learning processes & doing activities in unfamiliar situation-personal, social, professional & continued learning skill domain.

Other aspects of quality of learning are -

1) Reliability of students, performance
2) Conformance to students performance charactaistics to pre-established standard.
3) Durability of learning i.e. its usefulness over a longer period of time.
4) Serviceability: being easily trainable.
5) Aesthetics being pleasant, presentable, helpful & morally responsible.
6) Image favourably perceived by the public at large.

Professional educator has first to understand what these aspects of quality of students learning mean. These are the aspects which he/she will understand only when he/she studies "Theories of learning" & "Systems Theory as applied to education".

6.0 Class-Room Based Organized Teaching & Learning (Learning at the subject - level) :

Class-room based teaching-learning can be viewed as a system designed to assist a student to acquire organized body of subject level knowledge (knowledge, abilities & attitudes). This is the system's, output needed by the other subjects in the curriculum & also certain general curriculum objectives.

The systems diagram for the subject-level system is shown in fig.4. Using the system perspective, the professional educator can adopt a systematic procedure for designing & developing, implementing & evaluating teaching/ learning system. For example -

1) He/She draws a link diagram to locate the subject level system position in the total curriculum organization of all subjects.
2) He/She identifies the customers for the subject level systems output i.e. other subjects, curriculum objectives, roles at entry-level in the industry, society etc.
3) He/She designs output specifications i.e. subject level learning objectives (desirable knowledge skill & attitude)
4) He assesses signal input i.e. learner's entry-behaviour (current levels of knowledge, abilities & attitudes)
5) He/She designs "conversion process" i.e. teaching, learning systems. It consists of "structures". i.e. Teacher & Learners & 'functions' i.e. Teacher assessing learner's needs, designing content, selecting channel & transmitting message, Learner receiving message, decoding message & giving feedback to the teacher to take corrective measures.
6) Organizes "Maintenance inputs" (physical, human, information, energy, time, finances etc.)
7) Implements teaching - learning system.

8) Evaluates teaching - learning system & takes corrective measures.

It will be now clear that in order that the learner to be able to act as a learning system, effectively & efficiently, its environment i.e. subject level teaching - learning system has to be scientifically designed & implemented.

Only that professional educator can do this who is educated & trained in the following discipline called -

1) Nature of knowledge;
2) Basic principles of management of stable systems;
3) Basic principles of management of changing systems;
4) Technology of teaching & learning at the subject level.

Of course, the knowledge of (a) theories of learning, (b) 'systems theory' are foundation courses needed by all professional educators.

7.0 Total Course Curriculum Open System (See Fig. 5)

The total course curriculum also needs be viewed as a system designed to assist students to acquire total curriculum objectives i.e. acquisition of knowledge, abilities & attitudes needed by the industry at the entry-level & for smooth career development.

Systems diagram in Fig. 5 shows this. Using this system perspective, the professional educator can adopt a systematic procedure for designing & developing vocation specific curriculum. For example -

1) Analyse "General Environment" (Economic, Political, Cultural, Technological, Scientific) & find out how the general environment affects "task environment" (Industry, Community, Family, Students population).
2) Analyse "task environment" & assess what type of man-power supply they need in terms of roles & functions in the a) stable environment & b) changing environment.
3) Analyse roles & functions of a potential professional and design curriculum objectives (desirable outputs)
4) Analyse students entry behaviour (current knowledge, abilities & attitudes) for entry into the system. (signal input)
5) Design covnersion process by horizontal sturcturing of the individual subjects (placement of subjects with relation to one another) & vertical structuring of each subject.
6) Design "functioning" i.e. organization of teaching/learning with each subject (vertical integration of learning) & organization of teaching/learning across the subject areas (horizontal integration of learning to achieve curriculum objectives).
7) Design "maintenance inputs" for providing infrastructure to support curriculum processes & managerial action.
8) Organize resources for curriculum implementation.
9) Implement the curriculum.
10) Evaluate curriculum.

Once again, it will now be clear that if subject-level teaching-learning system is to be effective & effecient, it should have a supportive environment in terms of higher level supra system i.e. "total Course Curriculum System" which need to be scientifically designed & implemented.

Only that professional educator can

ensure this higher level system, who is educated & trained in (1) all disciplines mentioned earlier but specialized in (2) Curriculum design & development. This is the technology of designing teaching/ learning systems in the framework of total curriculum.

The quality of system functioning is measured by the quality of curriculum objective - whether student possesses core competencies needed to manage himself/ herself through his/her career growth and when faced with the changing situation. The quality is also measured in terms of the quality of conversion process :- teaching-learning process within each subject & across the subjects.

The quality is measured in terms of managerial process.

8.0 Educational Institute As A System :

Once again, individual curriculum does not *exist* in vaccum. It can exist with other curricula (say Diploma in Civil, Mechanical Electrical, Electronics engg). Institution can be viewed as a system (See fig. 6)

Using systems perspective, an institution can be designed & managed systematically. For example -

The purpose of institutional existence is to provide educational opportunities to student population across number of vocation in given domains of the industrial activities. (Civil, Mechanical, Electrical, Electronics etc.).

The procedure for designing an institution can be briefly stated as follows:

a) Analyse the environment (Economic, political, technological cultural, etc; Identify industrial network, social network, student population & public network), and Determine how it affects "task environment."

b) Analyse "task environment;" customers, their educational needs, regulatory authorities, suppliers of resources (information, physical resources etc.).

c) Analyse the role of the institution in this environment & function/services it has to provide to the customers.

d) Analyse current capabilities of the sutdents desiring to enter the institution. (Signal input)

e) Design "conversion process". First identity "structures" i.e. number & type of formal & non-formal courses to be planned & organized in the institution. Design Functions :- Role of each course & its interaction with the other courses - formal & non-formal.

f) Design "Maintenance input" for providing infra-structure to support conversion process & management process.

g) Organize resources for institutional operations.

h) Implement the institutional process of conversion resulting in the actual turning out educated quality professional.

i) Evaluate the institutional process & service for its quality.

If the curriculum processes are required to be effective & efficient, then it should have an effective environmental support in terms of "institutional planning."

The quality of institutional planning process is measured by (1) number of educated professionals which the institutions produces, (2) the quality of the students competence to be used at each area of vocations at entry level, for

career development & management of change, their continued learning skills, (3) amount of resources used to produce these products.

The professional educator at this level, can ensure the quality performance of this level of system, only if he/she is educated & trained in all above mentioned disciplines and also in the discipline of "institutional planning & management in education."

9.0 State Level Educational System (fig. 7) :

The purpose of the state-level educational system is to provide educational opportunities to the student population in the state to be able to develop competency necessary to enter into the industrial systems professional, semi-professionals, skilled & semi-skilled workers. This it does, through establishing new educational institutions throughout the state, developing industry-institute interaction & thus create educational opportunities in the institutions as well as in the industry.

The system manager should adopt scientific method of establishing such state-wide educational opportunities. Broadly, one can list following steps using systems perspective :-

a) **Analyse** the environment of this subjest-system; economic, technological, social, cultural etc. and find out how it affects "task environment".

b) **Analyse** "task environment" for assessing their needs: Customers, regulatory authorities, systems that supply students input, suppliers of resources & competitors.

c) **Specify** the role of the state-level education system & its services, it has to supply to their primary & seconary customers.

d) **Analyse** "signal input" to this system i.e. the current capabilities of the students entering into the system.

e) **Design** "conversion process". First, identify the "structures" i.e. number, location of the institutions in the state-educational, administrative, research etc. Second, describe the roles & functions of each of these structures & counter-roles of the organization with which these institutions will interact.

f) **Design** "Maintenance input" i.e. the resources required to support this "conversion process" i.e. physical, human, information & energy & time & financial resources.

g) **Organize** resources & its development.

h) **Implement** the "conversion process" resulting in the productions of educated professionals needed by the state.

i) **Evaluate** the performance of the state educational system & the effectiveness of the "conversion process."

This system at the state-level can be effective & efficient only when it is embedded in the national educational system.

The quality of this system at the state-level is measured by the quality of the students produced by the system in the entire state, the efficiency of the "process of curriculum" i.e. its educational institutes & process of interaction among them.

The professional educator at this level can ensure the quality of performance level of system, only if he is educated & trained in the discipline of "state-level

education of planning & management" **in addition** to all these disciplines mentioned earlier.

10.0 Management Of Systems :

It will be clear from the above description of systems development processes at various levels, that there are certain functions every systems manager has to carry out :-

(a) Systems Analysis; (b) System design; (c) System development; (d) Systems implementations and (e) Systems evaluation.

There are various functions related to the role of systems manager. While continuously trying to update & upgrade the system, the manager has to carry out **two tasks simultaneously** maintaining the dynamic process of the current system and upgrading that part of the system which needs improvement i.e. those parts which do not carry out goal attainment, adaptations, pattern maintenance and/or integration.

Management functions in both the tasks are different. One is called "Management of a stable system" & the other is called "Management of educational change."

Let us now look at each level & describe such management process at each level.

i) **At "student as a learner system level" :**

As there are changes in the next higher level system-subject level teaching/learning system, the student has to cope with learning traditional subjects, as well as learning new learning skills, acquire more complex thinking skills, complex body of knowledge & life-long learning skills.

Students must acquire the skills of managing his own learning.

ii) **At "Subject-level Teaching/ Learning Skill" :**

Teacher has to manage current subject-level curriculum, as well as manage acquisition of new teaching skills needed by changing concepts of students learning-continued learning skills & introductions of modern technology.

iii) **At the Curriculum of the total course level :**

The Curriculum in change has to co-ordinate the activities of all teachers to keep current level of teaching-learning activities going as well as organizing teaching and learning of all teachers to develop competence to achieve as a team the new revised curriculum objectives i.e. personal development, social development & continued learning skills and complex skills required in the professional practice courses by introducing new sophisticated technologies.

iv) **At the Institutional Level :**

The head of the institute has to manage current activities of institutional planning as well as developmental activities with the upgrading of the institutional functioning & resources to meet the customers new needs mentioned in Para 1,2,3 above & also to maintain effectiveness & efficiency of the institutional process.

v) **At the State Educational System Level :**

The Ministry Of Education as well as Directorate of Technical Education also have to maintain the current dynamic educational processes in the state as well as to manage change in the different parts of the system - educational, administrative &

research institutions - needed to upgrade the system to meet the challenge posed by social, cultural, technological & economic changes.

All professionals who are in charge of systems at any level have to know :

1) Basic principles of managing stable - system.
2) Basic principles of managing changing system.

In the second category, there are two major sub-concepts, each manager must know -

a) project management,
b) process consultancy.

Process Consultancy :

Changing systems involve changing the performance of individuals, team, sections, depts & organisations.

Changing performance involves learning & changing performance characteristics by individual, groups & organisations.

The transition of the learners from the current performance level to a higher level of quality is not a smooth process. Translating general knowledge in a specific situation requires **coaching by** the expert during the process of transfer. Coaching is also called process consutancy, because the intervention by the coach is aimed at improving the "Process of conversion."

This is a highly sophisticated skill, because the consultant should simultaneously help a person to carry out his/her task efficiently and effectively, but also maintain interpersonal relationships with the group and help the group interact with groups outsides its boundaries.

Manager in charge of systems change have to act as "process consultant."

11.0 Professionalisation Of Educational Personnel For Quality Performance :

The foregoing discussion makes it clear that if the quality of educational system as a whole has to improve, the system managers have to be professionally trained.

Hence there is a need to professionalize - (a) students, (b) teachers, (c) H.O.D./Deans, (d) principals, (e) state-level educational officials in the directorates & the Ministries.

Professionalization means :

1) Acquiring **scientific base** of the professional practice.
2) Acquiring **technology base** of the professional practice.
3) Acquiring **management base** of the professional practice.

Scientific base comprise :

a) Theories of Learning (behaviourical, social & cognitive);
b) Systems Theory;
c) Theory of knowledge;
d) Principles of management of stable system;
e) Principles of organizational behaviour and
f) Principles of management of change.

Technology base comprise :

a) Self-directed learning techniques;
b) Instructional design;
c) Curriculum design;
d) Institutional planning and
e) State-level educational planning

Management base :

a) Management of stable technology system;

b) Management of changing technology system and

c) Process consultancy.

12.0 Conclusion :

This paper is intended to stress that improving the quality of educational systems requires first understanding educational system as consiting of open system at various levels : students, teachers, curriculum, institutional and state level and how they are hierarchically related.

Following this understanding, one can then consider specifications of the quality of product, processes, input, resources and managerial practice at each level.

These specifications become the guiding points to the system manager to design, develop, implement & evaluate the new system.

But this process of systems change will be done only by professionals who posses sound scientific, technological & **managerial disciplines.** Mere expertise in the engineering knowledge is not enough. Then the managing systems change turns out to be a trial and error process and is more likely to devastate the system's morale.

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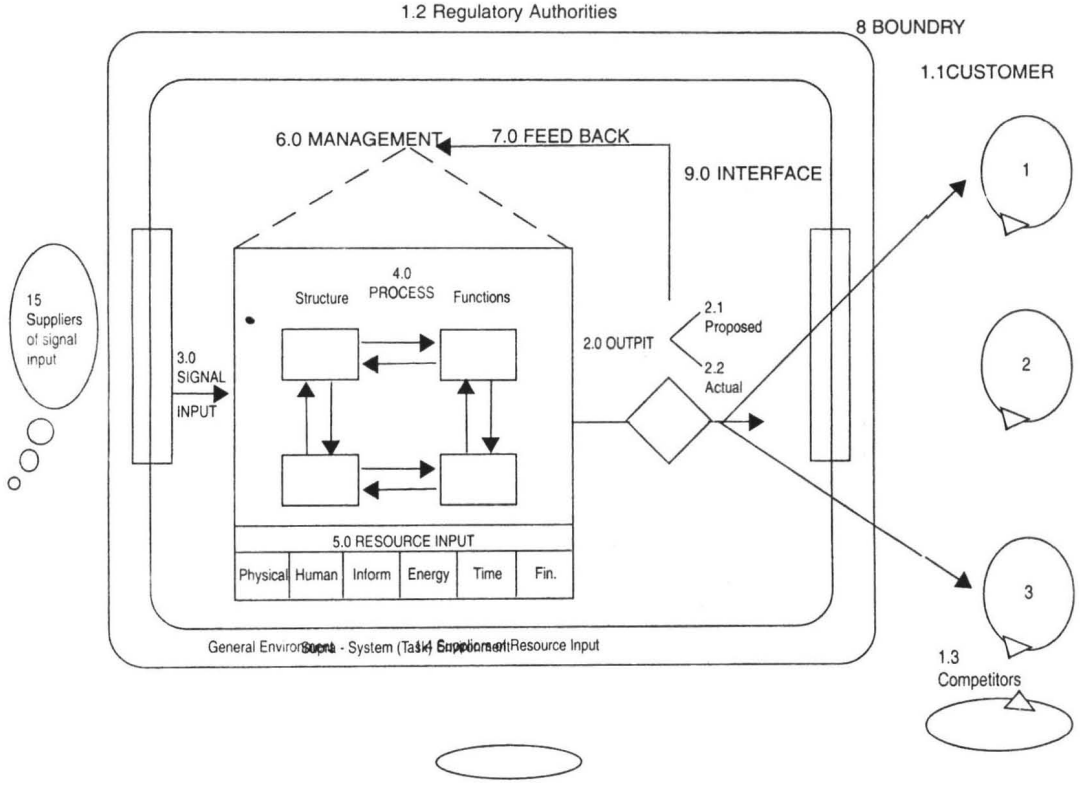


FIG. 1 : GENERAL SYSTEMS DIAGRAM

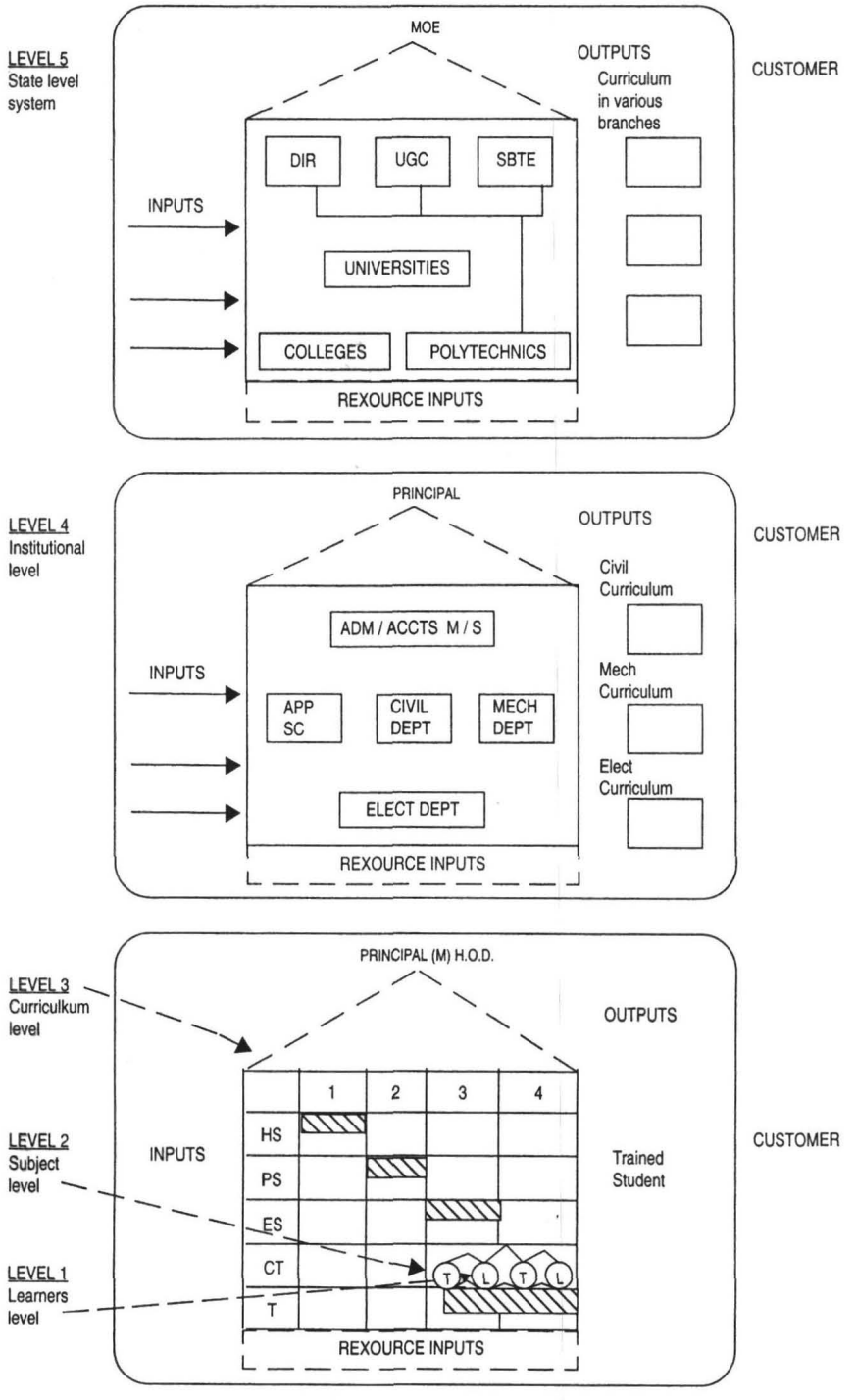


FIG. 2 : LEVELS OF EDUCATIONAL SYSTEMS

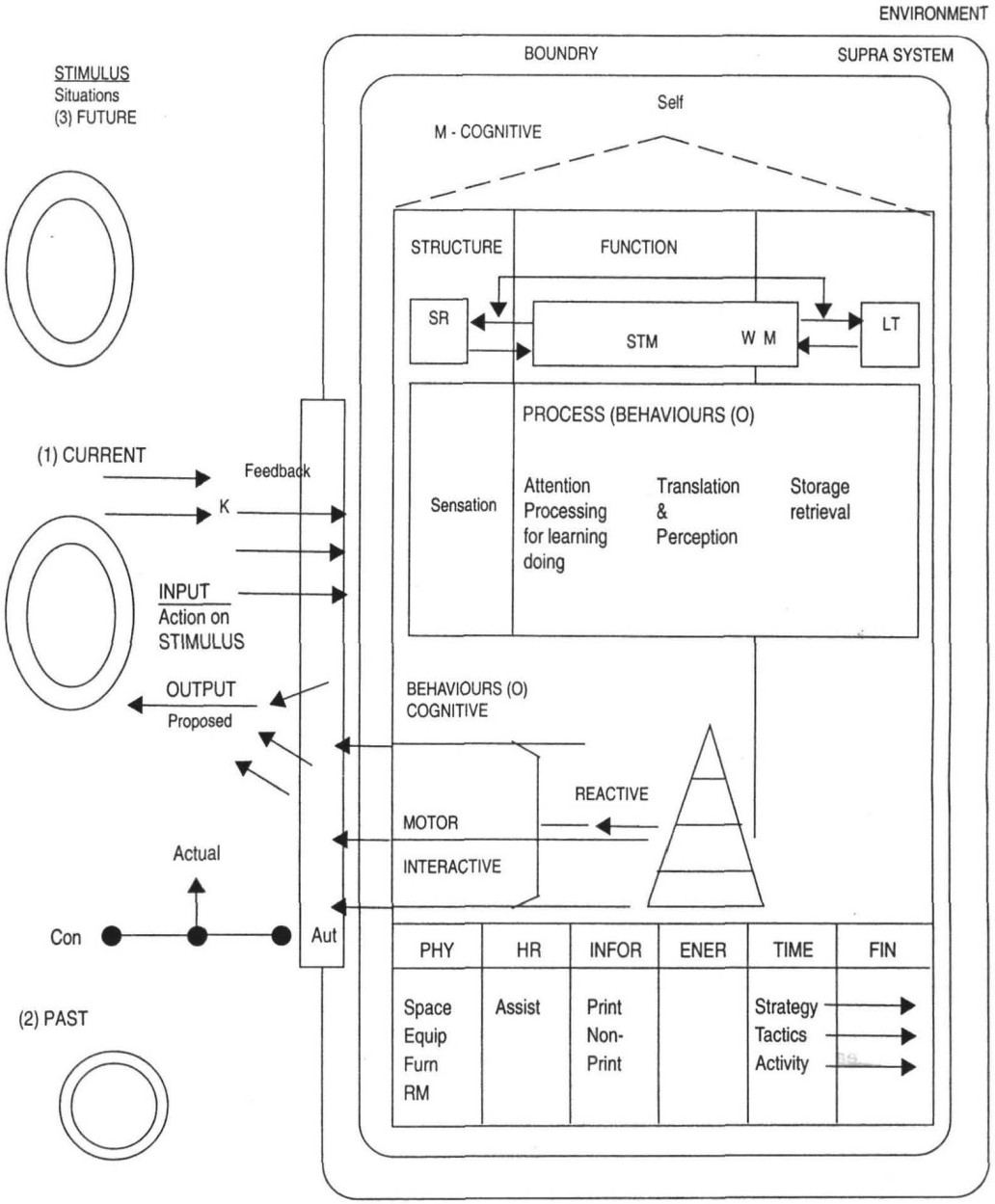
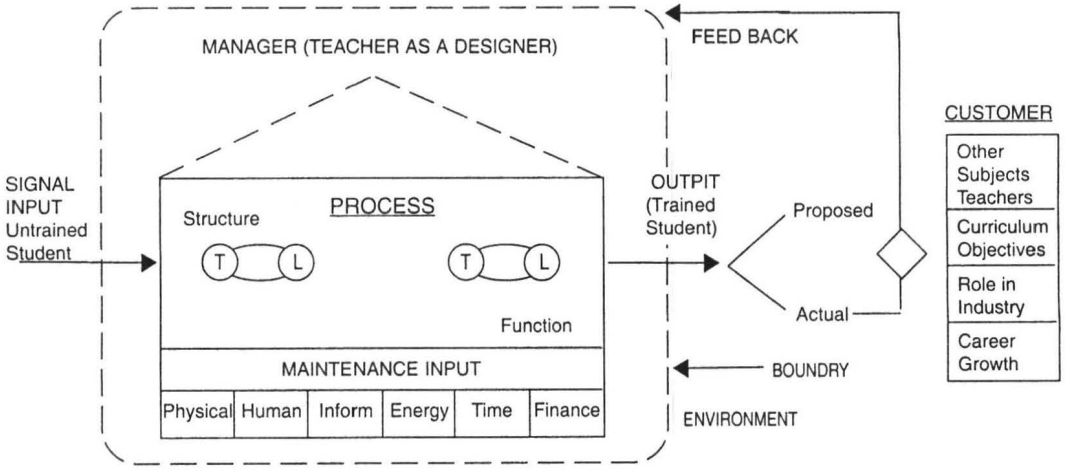


FIG. 3 : LEARNER AS AN OPEN SYSTEM



1.0 Environment

FIG. 4 : SYSTEMS DIAGRAM FOR SUBJECT LEVEL TEACHING.

COMNPONENTS	***DESCRIPTION***
1. OUTPUT Learning Objective	Desirable knowledge, skills, attitudes of each unit of subject.
2. SINGLA INPUT Students entry Behaviour	Current status of students abilities at the beginning of T/L system at each.
3. MAINTENANCE INPUT 3.1 Information 3.2 Time 3.3 Human 3.4 Finance 3.5 Physical 3.6 Energy	 ----- Topics ----- Chapters 1, 2, 3 ----- Units 1, 2, 3 ----- ----- Proportion time according to complexity of units ----- ----- Teachers & supporting staff ---------- ----- budgeting - Non-recurring & recurring ---------- ----- Space, equipment & furniture, tools consumable ----- ----- Electricity, Fuel ----------
4. PROCESS 4.1 Structure	 Teachers Role & learners role
4.2 Function a) Teaching b) Learning	Lecturers, tutorials, discussions, laboratory, practical, industrial training, testing & evaluation combined with Media = Print & non-print Listening, reading,observing, manipulating, reflecting, and giving feed back about learning.
5. MANAGEMENT Teachers as a designer	Assessing, designing, developing, implementing & evaluating teaching / learning system.
6. SUPRA SYSTEM	Other subjects, curriculum objects, role in industry & career development.
7. Boundary Interface	

FIG. 4.2 : DESCRIPTION OF COMPONENTS STRUCTURE.

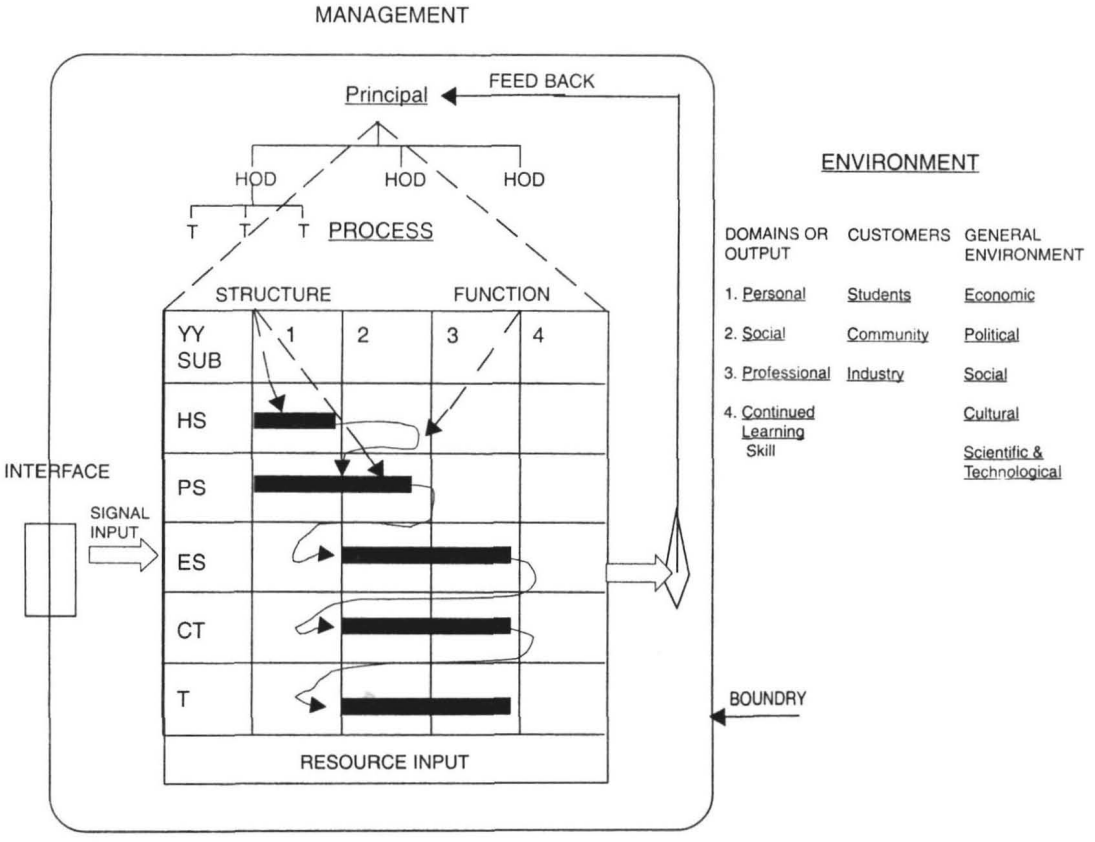


FIG. 5 : TOTAL CURRICULUM VIEWED AS A SYSTEM.

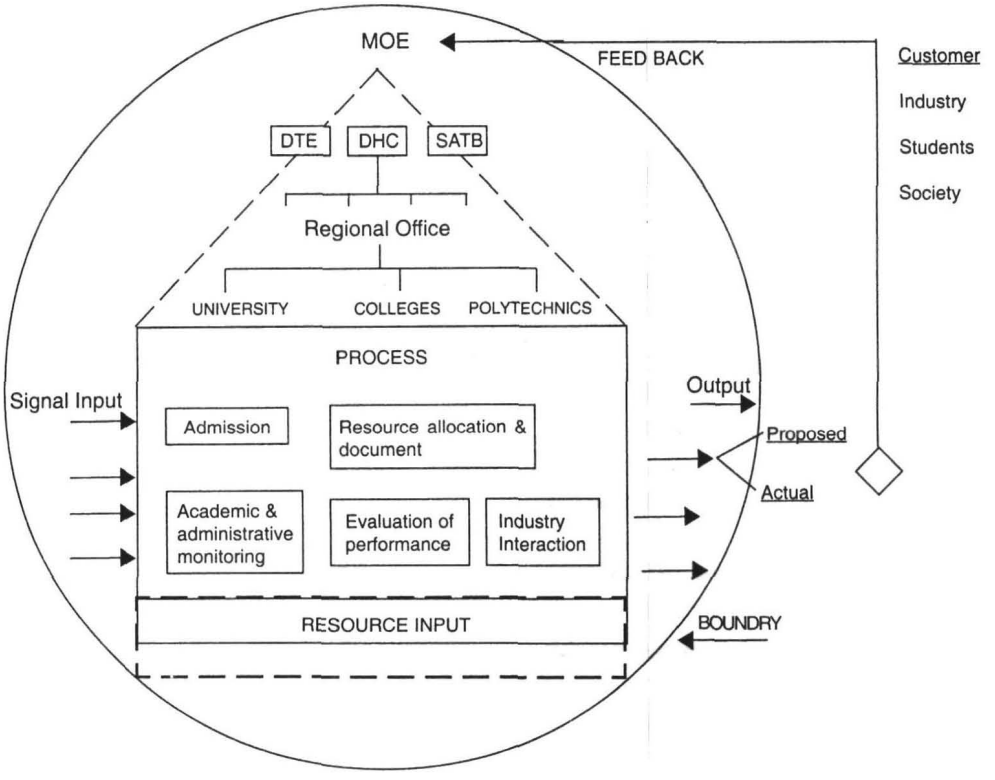


FIG. 6 : STATE LEVEL EDUCATIONAL SYSTEM AS AN OPEN SYSTEM

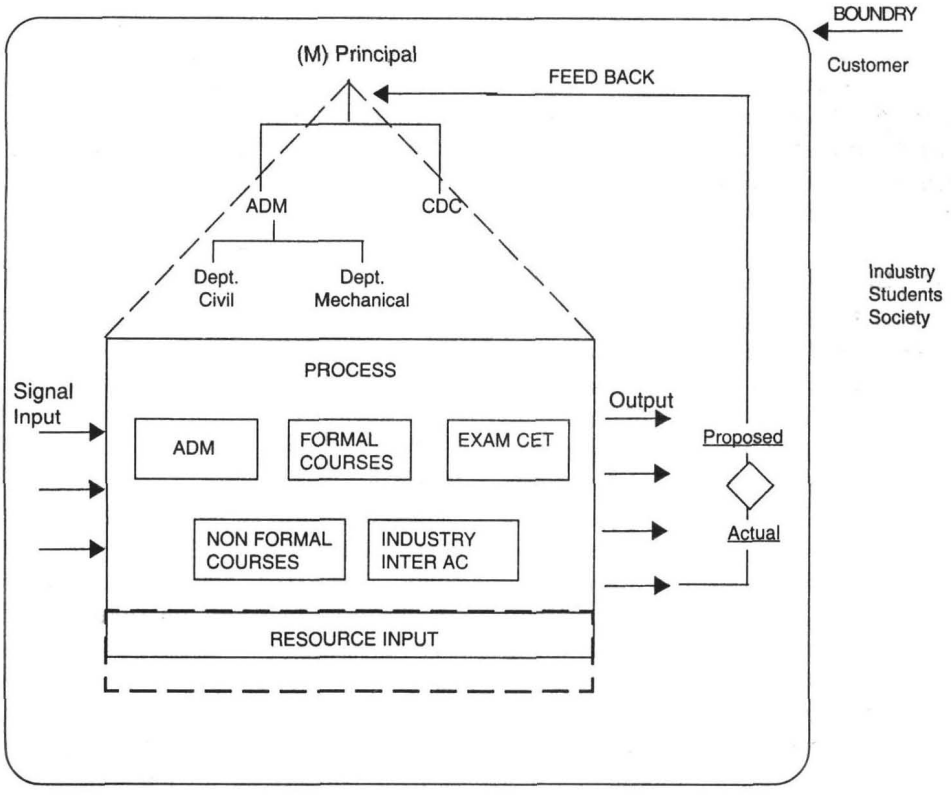


FIG. 7 : EDUCATIONAL INSTITUTE AS AN OPEN SYSTEM