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Systems Model for Improving Standards and Retention in Engineering Education

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Abstract

This paper describes a systems model for improving standards in engineering education and at the same time maintaining high retention rate for all engineering students in the educational system. A systems approach methodology adopted for this research is a technique of taking into account all relevant factors affecting quality education and student retention. A four-step procedure has been adopted for the model, namely: problem diagnosis, evaluation and analysis, system model design, and design implementation.

Introduction

Currently, in the United States of America, the demography indicates that the traditional source of American engineering pool of labor force (mainly White males) has declined and will continue to decline while ethnic minority population of Blacks, Hispanics, and women has increased and will continue to increase. Thus, the future of both industry and academic institutions will have to look at non-traditional sources of professional labor force, including future engineers and scientists in order to fill the thousands of jobs requiring a formal education in engineering. Therefore, there is an urgent need for new model of engineering education in order to improve standards and retention of all engineering students including women and ethnic minorities.

The paper discusses ten most important desired attributes (or standards) expected of engineering graduates. These attributes include: communication skills, technical knowledge, ability to define problems and come up with concise solutions, understanding the impact of engineering decisions on the environment, teamwork, creativity and critical thinking, appreciation for practical knowledge, importance of continuing education, engineers willing to work on factory floor, and understanding the concept of cross-functional training.

Systems Model for Improving Standards and Retention of Engineering Students

A systems approach methodology is a technique for taking into account all relevant factors when modeling a system or solving a specific problem. A schematic view the model for improving standards and retention in engineering education is shown in Figure 1. In this model a four-step approach has adopted. These four steps include diagnosis of the problem, evaluation and analysis, model design, and model implementation. The details of each step have been delineated in the figure. There are two major underlining principles behind this model and these are:

1. Capacity to prepare our children adequately and get them into engineering education.
2. The educational system must be such that it can keep the students in engineering, graduate them within a reasonable time with the best quality characteristics (high standards).

Considering the above two principles, a systems approach design model has been adopted in treating the entire educational process from pre-school through university level. Figure 2 provides a detailed schematic diagram for this global educational model developed by Owusu[1]. The model uses expert system and just-in-time techniques for the implementation and evaluation of the educational process. The major team players in this educational process are parents, educators, industry and governments. The emphasis discussed in this paper has been placed on engineering education at the University and college level, even though the concept is applicable to the general education system in the U.S. and to every country.

Expected Standards for Engineering Graduates (Desired Attributes of an Engineering Graduate)

The list presented here has been previous discussed in more detailed by Owusu as the expectations of Boeing Company (in Seattle, Washington State) for new engineering graduates[2]. The author compiled these desired standards of engineering graduate through discussions with management, engineers, and factory floor workers during a six-week “shadowing assignments” at Boeing Company in 1995[3]. This research was conducted to determine the attributes that universities should attempt to impart to their students as they go through the engineering education system, in order to meet the needs of their customers (i.e. entities that employ new engineers).

These ten attributes include: communication skills, technical knowledge, ability to define problems and come up with concise solutions, understanding the impact of engineering decisions on the environment, teamwork, creativity and critical thinking, appreciation for practical knowledge, importance of continuing education, engineers willing to work on factory floor, and understanding the concept of cross-functional training. These standards for engineering graduates have been assigned as part of the major outcomes for the model of engineering education, as shown in Figure 2.

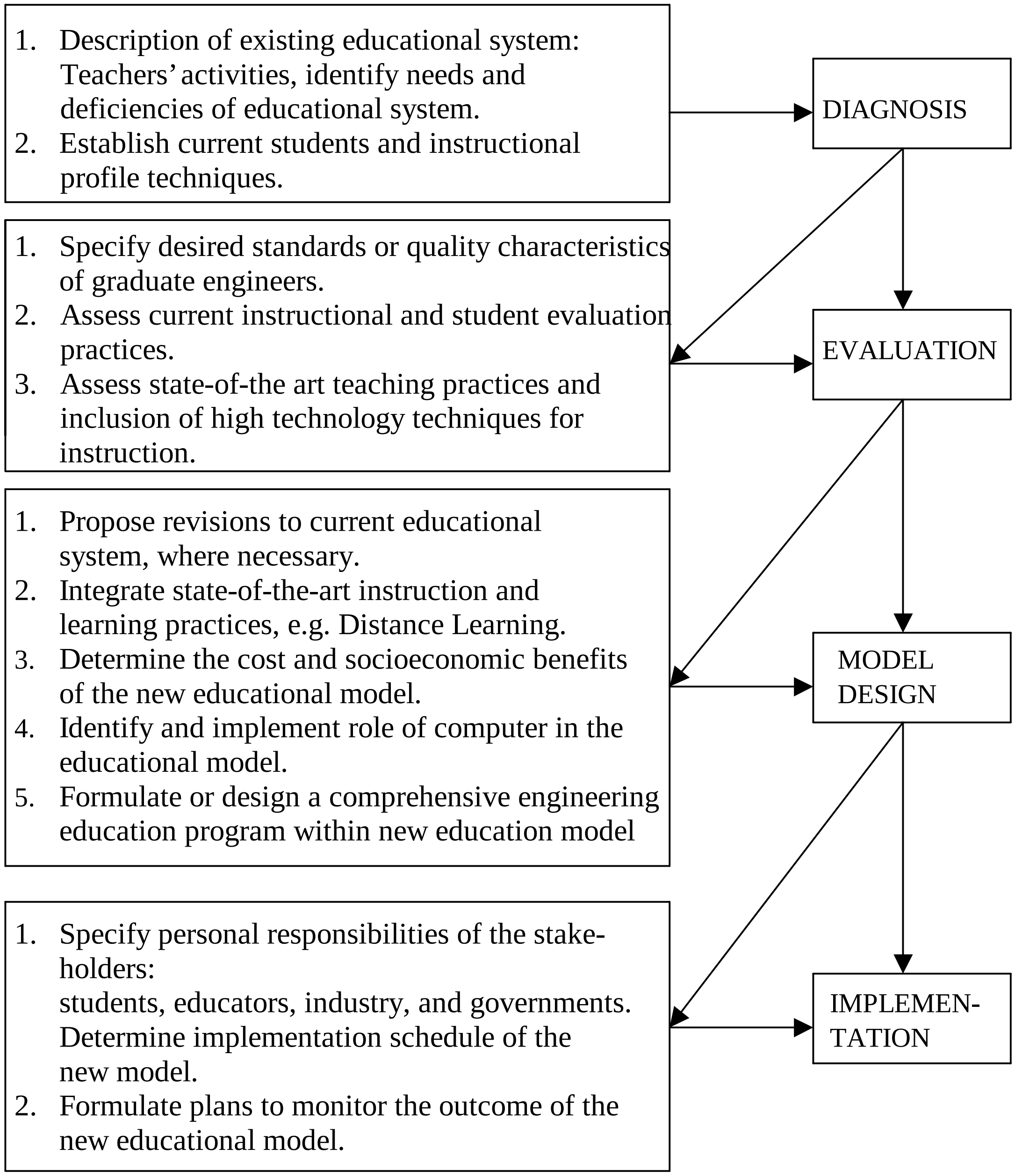
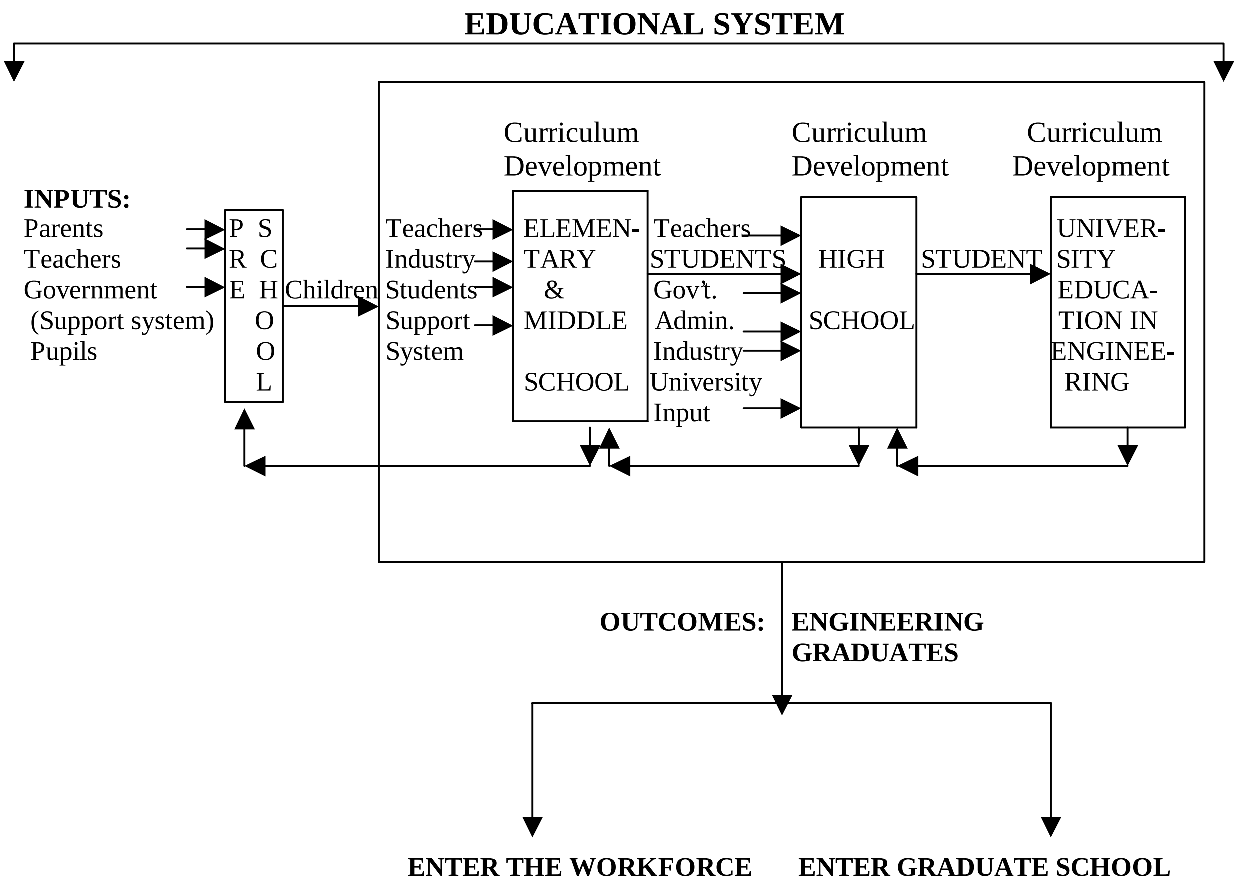


Figure 1. Schematic View of Systems Model for Improving Standards and Retention of Engineering Students[1].

Two sets of engineering graduates are the expected outcomes from this educational model: those who desire to enter directly into the workforce and those who desire to attend graduate school. Each outcome must have similar educational quality characteristics (standards) either into the workforce or into graduate school.



REQUIRED STANDARDS FOR ENGINEERING GRADUATES

1. Communication skills
2. Technical knowledge
3. Ability to define and solve problems
4. Understanding the impact of engineering decisions on environment
5. Importance of Teamwork.
6. Creativity and Critical thinking
7. Appreciation for practical knowledge
8. Importance of continuing education
9. Engineers willing to work on factory floor
10. Understanding the concept of cross-functional training.

Figure 2. Educational Program Model for High Standards and Student Retention.

The ten most important desired attributes found during the investigation include the following, as discussed in detail below.

1. Communication Skill
   - Engineers must be able to communicate well both in written and oral form.
   - Ability to prepare and deliver technical presentations.

- Must be able to communicate or promote their ideas to the management and their peers.

2. Technical Knowledge
   - Strong knowledge base in materials, materials selection, and chemistry of materials.
   - The interactive behavior of materials in different environments.
   - Manufacturing processes and finishing processes.
   - Strong background in probability and statistics, statistical process control, continuous quality improvement, and design of experiment.
   - Knowledge of risk analysis

3. Ability to Define Problems Clearly and Come up with Solutions
   - System design - analysis and synthesis.
   - Techniques of solving practical engineering problems.
   - Usage of computer as a tool, but not as a means to an end of solving all engineering problems.
   - Avoid being biased in engineering conclusions to problem solutions.
   - Understanding the interpretation of qualitative and soft data (incomplete and imprecise data).

4. Understanding the Impact of Engineering Decisions on the Environment
   - Must be knowledgeable on environmental issues, undesirable chemicals and processes.
   - Must understand how decisions on materials selection, processes, and manufacturing system selection affect the environment (concept of product life cycle).
   - Knowledge about design, costing, and scheduling based on deliverables.

5. Team Work (Concurrent Engineering) in a System
   - Concept of re-engineering through teamwork.
   - Being able to work in a system by understanding the philosophy and processes of a company as a system.
   - Know about the concept: plan, design, implement, and control.
   - Knowledge about organizational development, cost evaluation of design and research.
   - Understanding of business reality--profitability and cost reduction are the bottom lines.
   - Enthusiasm in team work environment.
   - Learn to build "team leadership skills" in an integrated production team (IPT) environment.
   - Focus on the customer need.

6. Critical and Creative Thinking
   - Capability to picture in the mind (in a three dimensional form) how to assemble complex components together into a whole unit (product).

7. Practical Knowledge (not the same as experience)
   - Reasonable "shop tolerance" capabilities.
   - Cost associated with tight tolerances.
   - Trouble shooting skills.
   - Awareness of difference between real world and modeled or laboratory world.

8. Concept of continuing education while working

9. Engineers must be willing to go to Manufacturing/factory Floor to work with Shop Floor people to help solve problems.

10. Understand the Concept of Cross Functional Training/Learning (in order to satisfy customer needs).

An expert system technique has been used to control student progress and retention as students move through the system.

Expert System Model for Controlling Retention in Engineering Education

An expert system application is used in the model to solve the retention problem in engineering education. The expert system attempts to match students' interests with academic area and the courses in which they need some tutorial help. Students who have problem are detected early in the process; and requisite assistance is provided before it is too late to fix. Figure 3 shows how an expert system model used to match the research interests of qualified students with research areas being investigated by faculty members, State Research Centers, Private Industry Research Centers, and National Research Laboratories such Argonne, Oak Ridge, and Sandia.

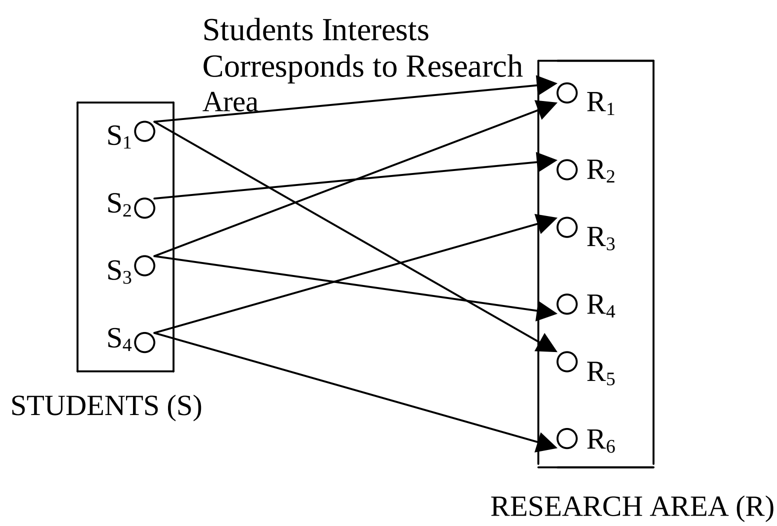


Figure 3. Expert System Application Model for Retention in Engineering

Schematic diagram of a control model for retention and quality characteristics in engineering education is shown in Figure 4: a system with inputs and outputs (engineering graduates).

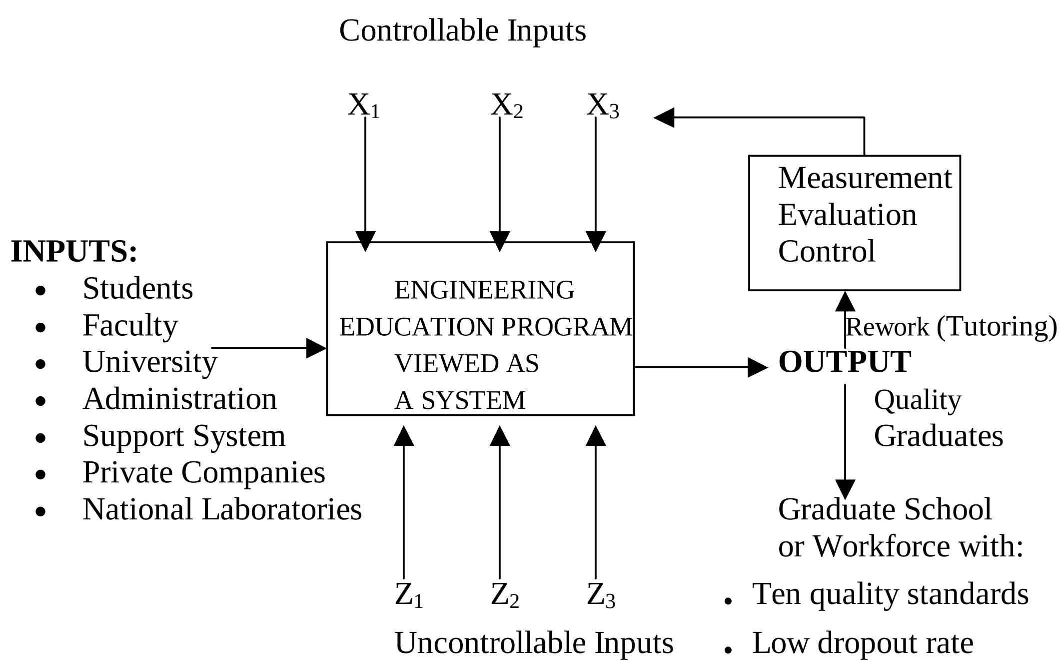


Figure 4. Schematic Diagram of a Control Model for Retention and Maintaining Quality Standards for Engineering Education.

The controllable inputs X_1, X_2, X_3, ----X_p include such factors as student previous background, student study skills, faculty teaching experience, and support system in place. The support system include such things as tutorial program, financial aids, research activities for student participation with faculty members as mentors. The uncontrollable factors Z_1, Z_2, Z_3, ------ Z_p represent such factors as sickness and other environmental conditions. Those controllable factors must be addressed early during the educational process as students pass through the education system indicated in Figure 2.

Concluding Remarks

The model developed in this paper for engineering education takes into account a team approach to the educational process in which educators, industry, government organizations, and parents participate in the education system from pre-school to the university level. The backbone for this model is new curriculum design to take advantage of new Internet technology in which courses can be tailored to satisfy different students needs and learning abilities. Computer usage must be encouraged and used to enhance instructions and learning processes.

Bibliography

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