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CONCEPTION, DESIGN AND DEVELOPING AN INTELLIGENT EDITOR FOR MODEL-BUILDING PROCESS*

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Key words and phrases: modeling of learning; modeling of teaching.

Abstract: The model interpretative nature and its quantitative formulation constitute the most appreciated characteristics of models. At the present paper, an Intelligent Editor for modeling teaching and learning is developed. System helps students to develop modeling skills. The most complex task in OR consist in problem formulation and model formulation. In this process is necessary to translate the problem formulation from the verbal model to mathematical model. Here is proposed an Intelligent Editor in order to help students in model-building process. The main objective of the present paper is to analyze the design and work with the Intelligent Editor. The system was implemented in C++ for microcomputer.

Introduction

Intelligent Editor system can be defined as a strong related set of informatics software tools and modules that has as the main objective to increase the efficiency of the teaching and learning processes in Operations Research.

The improvement of the quality of teaching and learning process stimulates the emerging of new educational methods and technologies. At the present paper, it was established as the main objective to improve the teaching and learning process by means of a hypermedia intelligent tutoring system (**HITS**). In this relation, the idea of designing an intelligent system for Operations Research teaching and learning emerged.

One of the main and most complex problems in OR learning and teaching is associated to model building. Like Wagner (3), we think that: «Model design is the essence of Operations Research». In spite of this brilliant idea, nowadays continue without conscientious study the problems associated with model design. This fact put in evidence, the considerable and existent gap between theory and practice in OR teaching and learning.

The considerations and ideas formulated before stimulated the idea of developing a new and special software tool to help students and professors in problem solving

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associated to Linear Programming models. This software tool was named and it has as the main objective to help and advice students and professors in the processes associated to model formulation and problem solving in Linear Programming courses. Intelligent Editor must be available to:

1) generate the model of any LP problem;

2) compare it with the mathematical model formulated o proposed by the student;

3) recommend to student a problem more or less complex depending of his results;

4) evaluate the student work systematically;

5) send a final report on student work, in which are included:

a) student's mistakes and explanations;

b) congratulations.

Intelligent Editor gives the student the possibility of training and to evaluate his work if desires it.

Automation Object

Models have become widely accepted as a mean for studying phenomena, but the processes involved in the math modeling formulation have continued been very complex and ill structured. To define mathematically some part of the real world, it is necessary to develop an appropriate math model relating the one or more relevant variables. The purpose of the model might be, for example, to determine the best way of blending raw refinery stocks to yield aviation and motor fuels. No model is ever an exact image of the real world. Approximations are always necessary. One of the main tasks in OR science is model building. In model building we start with a construction of a verbal model of the real system and the refine it until it can be translated into math expressions. Translation is a complex and slow thinking process.

In model building we start with a construction of a verbal model of the real system and then refine it until can be translated into math expressions. Translation is a very complex process. However, the real problem in going been from the verbal to math statement arise when the initial verbal model is not an adequate description of the real system and the shortcomings of the verbal model are revealed in the attempt to translate. Last formulations revel two of the main problems in modeling:

1) the establishment of adequate relationships between the real system and verbal model (idealization process);

2) the translation from verbal model (word problem) into math model.

Firstly, the acquisition of skills on idealization of physical, economic, social or military phenomena by students constitutes a complex and slow learning and thinking process. Ackoff (1968) said: «The quality of a model depends very much of the imagination and creativity of the research team. Intuition, insight, and other mental operations that are essentially uncontrollable play a major role in the process. It is not possible, therefore, to prepare a manual of instructions for model building. If such a manual could be prepared, it would be more likely to constrain than promote creativity. Nevertheless, when past experience in model building is examined, certain patterns emerge…» [1].

Secondly, for most students working with LP algorithms become rather easy with training. The part of the OR, they find most complex is the model building. It is a considerable conceptual mistake to suppose that acquisition of modeling skills arises mysteriously through OR teaching and learning process. Commonly, the characteristics of idealization process are not well explained, in OR course, as a powerful theoretical and practical method of knowledge acquisition. Through OR courses the students acquire some skills on abstraction method from generalization of particular situations. However, the idealization process requires not only, to be able to do abstractions, but to be able to define the main and trivial variables. This problem emerges frequently in science and technology, but OR teachers have not learnt how to teach it. I think that it is necessary to explain how have been produced the scientific discoveries through the history.

The second problem has been more analyzed than the first. In this relation Wagner (1969) said: «Surprisingly, it is difficult to write a verbal description of an OR problem that is completely unambiguous. More than once, thoughtful students have discovered vague wording in problems that had assigned previously to other classes that experienced no difficulty in obtaining the intended solutions. Many OR texts develop students' skills in translating a verbal model of a problem into an equivalent math model. For most students great difficult in solving OR word problem. The method used by most of these students is the memorization method. They read a problem quickly, and then search their memory in the effort to find an analogous problem that seems to be related to the problem. Once, they find it; substitute the parameters of the problem in the math model. For these students problem-solving becomes a matter of guessing and blind link [3].

A better way to solve PL problems used by the most successful students and engineers involved learning a process or strategy that can be applied to any problem. This problem-solving strategy involves 5 important stages:

1) problem formulation;
2) model formulation;
3) finding a solution;
4) implementation;
5) improvement.

The main objective of the present paper is associated to the analysis and investigation of Problem Formulation and Model Formulation stages.

Problem Formulation and Identification

In order to obtain a clear conception of the system behavior, it is necessary to study initially its structure and relations, to define the inputs and outputs, to determine the appropriate objectives, the constraints on what can be done, the possible alternative courses of action, time limits for making decisions, etc. This process of problem formulation is crucial. Determining the appropriate objectives is a very important aspect of problem formulation. In order to identify the problem, it is convenient to formulate a set of questions like as:

1) What kind of problem is this?
2) Have been known or worked any analogous problems?
3) Has the problem some characteristics that remind another problem solved before?
4) What kind of variables can be used in problem solving?
5) What data are known and unknown? and others.

The essence of the problem formulation stage is to obtain a general conception of the system behavior and its functions. In this stage it is convenient to draw a general system diagram to obtain a better understanding of the system and its functions. One key to successful problem solving in PL is to start at the end.

Model Formulation

After formulating the decision-maker's problem, the next step is to reformulate this problem into a form that is convenient for analysis. The conventional OR approach for doing this is to construct a mathematical model that represents the essence of the problem. A crucial step in formulating the math model is constructing the objective function. This requires developing a quantitative measure of effectiveness relative to each objective. If more than one objective has been formulated for the study, it is then necessary to transform and combine the respective measures into a composite measure of effectiveness. In model formulation stage it is necessary to translate the problem from NL sentences to OR objective function and restrictions. It is necessary to translate a PL problem bit-by-bit and phrase-by-phrase into math expressions. In this stage, the information available is simplified and symbolized by the OR team. Almost all thinking and problem solving that students and engineers develop requires that they handle NL. Often they must perform tasks that also require math manipulations. Language is one of the essential aspects of human behavior. From the first stages to actual stages, language has had a considerable evolution in the history of the humanity. Language has influenced in sensible form in the social and scientific development of human being. The development of writing was a great revolution in human thinking. It created the necessary conditions to record the knowledge and experiences of human groups and peoples from one generation to another. It has contributed in sensible form to develop of history and logics. In its spoken form, language is the main human tool for diagnostic, planning, coordinating and managing the collective activities. Since ancient times, the meaning of sentences and texts had been one of the main problems of NL understanding. This problem is associated with the fact that most words have multiple meanings. Ambiguity would inhibit the system from making the appropriate influences needed to NL understanding. To solve the problem of meaning, it is necessary to use a more precise language. The tools to do this come from logics and involve the use of formally specified representation languages. Many of the first attempts at using computers to process NL concerned the problem of translating from one NL text into another. By translation we understand at the present paper, the operation or process of changing one expression or set of symbols in NL into another expression or set of symbols in formal language or mathematical terms [1–18].

Blending problems

Some of the earliest applications of LP took place in industry. A factory, process or department can be analyzed as a «system» that has certain number of inputs and outputs. The inputs can be, for example, raw materials, crude oils, sugar cane and others, that are processed within the «system», while the outputs can be considered as the products that are elaborated within the system. They can be equipments, gasoline, sugar and others. One of the most known industrial processes are mixing or blending. A mix or blend, it is considered here as an operation or process of combining two or more ingredients, components, or constituents, like as, raw materials, craw oils, sugar and others, which present certain features to form an integrated whole with certain quality and technical requirements. The most commonly observed characteristics are: density, moisture, viscosity, color and others. The proportions of the blend are adjusted to give the product certain desired properties. Different types of products can be made that have different specifications. Given the volumes and the properties of certain streams coming out of the factory, the problem consist of determining how these streams are to be mixed so as to make the specified types of products in an optimal way.

Without loss of generality, we decided to limit our research domain to the blending-problem model formulation, since they grade of generality in OR field. Like it is known, to model a blending problem, it is necessary to know the quantity and the name of the raw materials and final products, like as, raw materials availabilities and technical requirements. On this base, the student can analyze the relations between the main elements of the problem. On this base, he can formulate the decision variables, objective function and constrains, associated with the blending problem. Taking into account the information introduced by the student, the system is able to compare these data with the model's data constructed automatically by the expert module. The comparison between both models permits to find the mistakes made by the student, if there are. When the system detects some mistake, it informs on them to the student and gives him several explanations and recommendations. This process can be repeated three times. If during the process the student cannot introduce the correct model, then the system finalizes the work and sends a final report evaluating the student work. In the report it gives several recommendations. Between them, the system can recommend him to solve a problem with a lower level of complexity and proposes a new problem with these characteristics. On the contrary, if the student models correctly the OR problem the system proposes him another problem with a higher level of complexity. Finally, the system generates an evaluation on student work. The student evaluation is registered in the DB.

Problem Statement

Suppose a mix problem within the context of a simplified paper factory. Consider that the factory wishes to blend 2 constituents into one product (Bond Paper). Then the problem consists in determining the mix of constituents (raw materials) that will maximize profit.

The availability and costs of the constituents are the following:

No.	Constituent	Availability in Tons	Cost per Ton
1	Wood Fiber	1000	800
2	Returned paper	800	200

To maintain the required quality of each product it is necessary to specify certain maximum or minimum percentages of the constituents in each blend. These are given below, along with the selling prices for each product.

No.	Product	Specification	Selling Price per Ton
1	Bond	Not less than 10 % of Wood Fiber; Not more than 70 % of returned paper	1000 $/Ton

Formulation

Before attempting to write down a LP model careful consideration should always be given to the proper definition of the decision variables. Although this is often obvious it some times becomes the heart or the essence of the problem solving. After clearly identifying what information is really desired and the most convenient form for conveying this information by means of decision variables, it is usually easy to write down the objective function and the restrictions on the values of these decision variables. In the blending problem, the decisions to be made are well defined, but the proper means of conveying this information may require a little thought.

Variables definition

X(FM, B) … number of tons of Wood Fiber that participate in the blend of Bond paper;
X(PR, B) … number of tons of returned paper that participate in the blend of Bond paper;
X(Bond) = X(FM, B) + X(PR, B)
The total profit Z is given by:
MAX Z = Price (Bond) * (X(FM, B) + X(PR, B)) – (Cost (FM) * X(FM, B) + + Cost (PR) * X(PR, B))
The proportion of constituent Wood Fiber in blend of Bond paper is:
X(FM, B) $\geq$ 0,1 * (X(FM, B) + X(PR, B))
The proportion of constituent Returned Paper in blend of Bond paper is:
X(PR, B) $\leq$ 0,70 * (X(FM, B) + X(PR, B))
Hence, the model is to maximize Z subject to the restrictions imposed by the availability of constituents and the blend requirements and by the restrictions of non negativity Xij $\geq$ 0.
X(FM.B) $\leq$ Availability of Wood Fiber
X(PR, B) $\geq$ Availability of Returned Paper
Finally, we obtain the following model for blending problem:
MAX Z = 1000 * (X(FM, B) + X(PR, B)) – (800 * X(FM, B) + 200 * X(PR, B))
MAX Z = 200 * X(FM, B) + 800 * X(PR, B)
Subject to:
X(FM, B) $\geq$ 0,1 * X(FM, B) + 0,1 * X(PR, B)
X(PR, B) $\leq$ 0,70 * X(FM, B) + 0,70 * X(PR, B)
X(FM.B) $\leq$ 1000 tons
X(PR, B) $\geq$ 800 tons
Simplifying, we have:
MAX Z = 200 * X(FM, B) + 800 * X(PR, B)
Subject to:

– 0,90 * X(FM, B) + 0,10 * X(PR, B)	$\leq$ 0
– 0,70 * X(FM, B) + 0,30 * X(PR, B)	$\leq$ 0
X(FM.B)	$\leq$ 1000 tons
X(PR, B)	$\leq$ 800 tons

Intelligent Editor Structure and Design Conception

The essence of the problem formulation stage is to obtain a general conception of the system behavior and its functions. In this stage it is convenient to draw a general system diagram to obtain a better understanding of the system and its functions. One key to successful problem solving in PL is to start at the end.

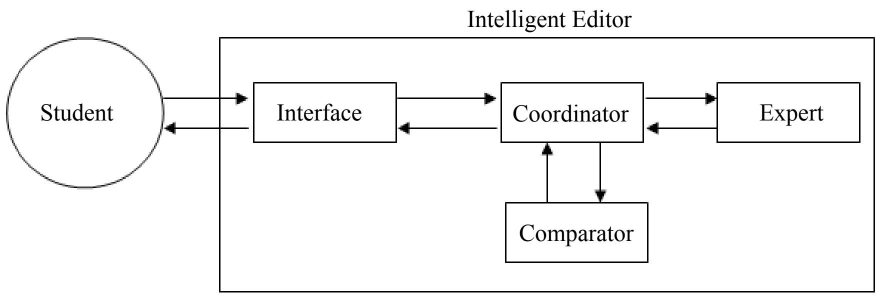

Fig. 1. Intelligent Editor structure

In order to understand the role and functions of the Intelligent Editor, suppose that a student using Intelligent Editor system wishes to solve certain LP optimization problem. In this relation, he has two alternatives: 1) training; 2) evaluation. On this base, the student most formulate an OR model of the analyzed problem. Suppose too this OR problem is a blending problem. To formulate a blending model the student must know the name and the quantity of raw materials and final products, costs of raw materials, prices of products, technical requirements of blend and availabilities of the raw materials. Based on these data he draws the system diagram. Then, the student defines the decision variables, the objective function, and constrains.

In parallel with the student work, computer system models the OR problem and saves the model in the computer memory. In this relation, the system compares the model formulated by the student with the model constructed by the expert. As result of this comparison, the system can discover possible mistakes. If, there is some mistake, then the system informs on them to the student and gives several explanations related with these errors. This process can be repeated three times. If the student finally cannot find his mistakes and formulate correctly the model, then, the system sends to him a final reporting which shows the correct model and explains the difficulties the student presented. The system can recommend to student to solve another problem with the same complexity level or with the lower complexity level, when the student cannot find the correct model. On the contrary, when the student is able to solve correctly the model, then the system recommends him to solve a new problem with a higher complexity level. Fig. 2 and 3 show the interface of Intelligent Editor. By means of these interfaces students may introduce the data for modeling.

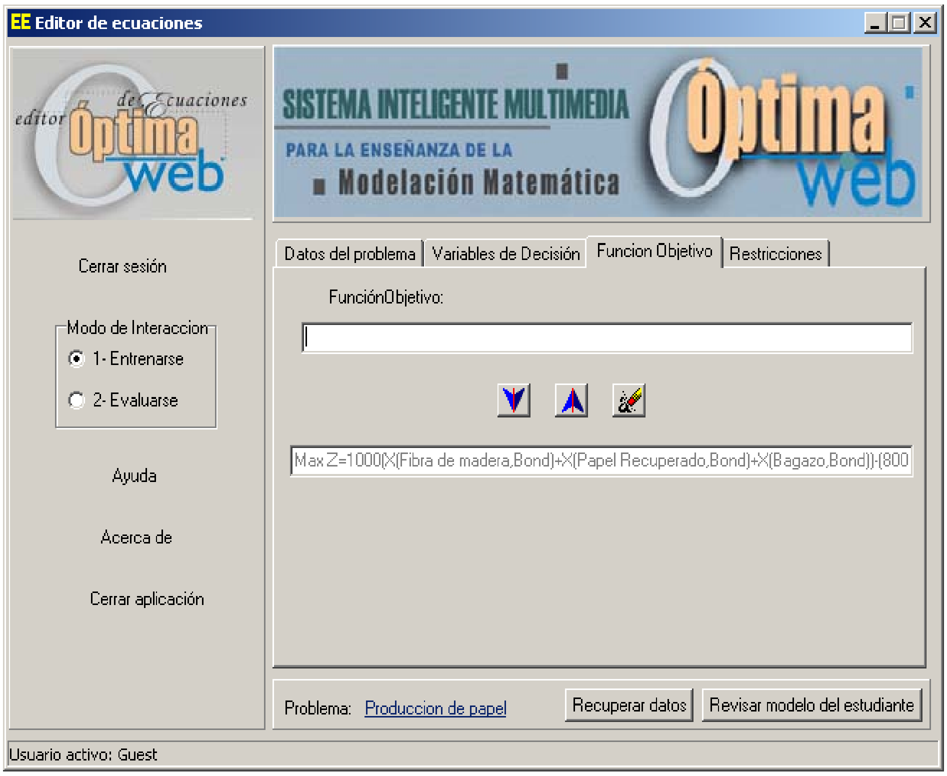

Fig. 2. Definition of the Objective Function

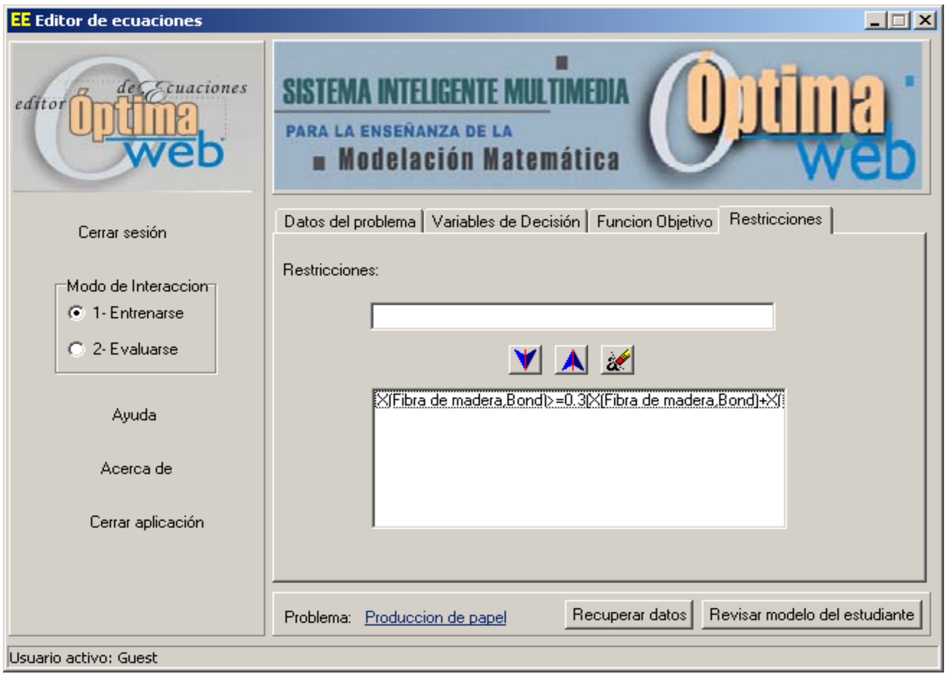

Fig. 3. Definition of the problem constraints

Conclusions

The designed and implemented Intelligent Editor for optimization problems contributes to reach the OR teaching goals. Using the system student can analyze different problem situations and system representations. This facility improves the student's relations with the reality and allows him to develop modeling skills. Implemented system stimulates the student active participation in teaching and learning process. It has been applied by Cuban university informatics' students in their projects and thesis works for several years with successful results.

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Концепция, проектирование и разработка Интеллект-редактора для процесса построения модели

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Ключевые слова и фразы: моделирование обучения; моделирование преподавания.

Аннотация: Интерпретационная природа модели и ее количественное выражение составляют наиболее значимые характеристики моделей. В настоящей статье рассматривается Интеллект-редактор для моделирования процессов преподавания и обучения. Система помогает студентам сформировать навыки моделирования. Наиболее сложными представляются постановка проблемы и построение модели. Для этого необходимо перевести формулировку проблемы от вербальной модели к математической модели. Предлагается Интеллект-редактор для оказания помощи студентам в процессе построения модели. Основная цель настоящей статьи проанализировать проектирование и работу Интеллект-редактора. Система была реализована в C++ для микрокомпьютера.

Konzeption, Projektierung und Entwicklung des Intelligenz-Redakteurs für den Prozess der Modellbildung

Zusammenfassung: Interpretierungsnatur des Modells und ihre Quantitativäußerung bilden die bedeutsamen Charakteristiken des Modells. Im vorliegenden Artikel wird den Intelligenz-Redakteur für die Modellierung der Unterricht- und Lehreprozesse betrachtet. Das System hilft den Studenten die Fertigkeiten der Modellierung zu formieren. Die Problemstellung und die Modellbildung sind kompliziert. Dazu muss man die Formulierung des Problems vom Verbalmodell zum matematischen Modell übertragen. Es wird den Intelligenz-Redakteur für die Hilfe den Studenten im Prozess der Modellbildung vorgeschlagen. Das Hauptziel dieses Artikels besteht in der Analyse der Projektierung und der Arbeit des Intelligenz-Redakteur. Das System wurde in C++ für Mikrocomputer realisiert.

Conception, projection et élaboration de l'Internet-rédacteur pour le processus de la construction du modèle

Résumé: La nature d'interprétation du modèle et son expression quantitative présentent les plus valables caractéristiques des modèles. Dans le présent article est examiné l'Internet-rédacteur pour le modélage des processus de l'enseignement et de la formation. Le système aide les étudiants à former les savoirs du modélage. Le plus difficile c'est la mise du problème et la construction du modèle. Pour cela il est nécessaire de réaliser la formation du problème du modèle verbal à celui mathématique. Le but essentiel de cet article et d'analyser la conception et le fonctionnement de l'Internet-rédacteur. Le système a été réalisé en C++ pour le microordinateur.
