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THE DEVELOPMENT OF TEXTBOOK EXERCISES FOR CHEMICAL ENGINEERS

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ABSTRACT

The development of the exercises that exemplify the theory, or the so-called problems in Chemical Engineering textbooks, are not an easy task and in most cases they are done at random. There are some authors that have proposed a methodology for the development of the exercises, but in the textbooks of chemical engineering such methodologies are not used. In this article the author proposes a methodology that have been used for thirty years in his classes and in his textbook exercises.

KEYWORDS: *Chemical Engineering, problems, skills, knowledge,*

1. INTRODUCTION

The exercises or problems not only allow the landing of concepts, but they are used to clarify the methodology used to solve problems. There is a broad recognition that one of the major flaws of the educational system is the inability of the student to apply the acquired knowledge to new situations and solve problems. However, there is little awareness that this problem has its main source in the characteristics of the instructional materials, particularly texts, and in the activities of teaching and learning that are based on these materials.

In many texts, the exercises are scarce and merely illustrative, in other there are numerous problems and exercises at the end of the chapters to be resolved as a task for the student, without any help. In many cases the text are conceived only as a means to expose the knowledge of the discipline, but not to apply that knowledge. The differences between the texts lie almost exclusively in the organization and depth with which the different theoretical topics are addressed but not in the form in which the problems are solved.

Many authors of text share the traditional idea that resolution of problems skills are acquired spontaneously and basically depend on the talent of the student.

However, educational research has shown that problem-solving requires knowledge and specific, identifiable, strategies that can be taught.

Solved exercises is an important part in chemical engineering books, and they must show the necessary procedures to achieve the result through detailed examples and problems type.

1.1. What is a problem?

Although some people have defined a chemical engineer, as a solving problems professional in the field of chemistry and related industries and despite all the interest in problem

solving manifested by the large number of publications and courses offered on the subject, there are not specific courses on how to solve problems.

But what is a problem? According to dictionary, "it is a set of facts or circumstances which hinder the attainment of an end, or can also be set as a new situation you need to address or resolve and for which there is no immediate solution".

Therefore, the resolution of problems is an acquired competition or skill that involves a whole of techniques and activities that allow to obtain answers to a question under a group of given conditions.

There are many skills and knowledge that come into play to solve a problem, among the most important are:

- ✓ the ability to discriminate the relevant from the irrelevant,
- ✓ the ability to generate original ideas and/or provide alternative solutions to a problem and,
- ✓ the ability to plan and carry out an objective.

These skills can be developed in summary by exercises, however, it is best to develop them solving, properly, problems related to the profession in contextual situations.

1.2 Models to solve problems

There are several models to explain problem solving as a human activity:

a) Behavioral model: problem solving is a process of trial and error, composed of three principles: stimulus (problem), answer (solution) and reward (consequence).
b) Cognitive model: psychologists try to explain the solution to a problem as a conscious process. For them the solution can come as a whole screen (a decision of conscience or insight) they perceive the habits and conformity as something that negatively affects the resolution of problems
c) The experimental model: this model is based on experimentation and observation of those who successfully resolved a problem in their work.

Under these models some authors have attempted to define the way of solving problems in order to facilitate its solution or make it explicit and formative.

In 1957, Polya [1] published a four-step procedure: definition, planning, action, and evaluation.

After this publication, some professors have developed numerous methods for the resolution of problems, most of them being variations of the Polya.

Polya model begins with the definition of the problem (what, where is it?), then comes the planning or the form or forms that can be attacked the problem, followed by action or resolution, stones, or manufacturing, to finish with the evaluation of the results.

TABLE I. Some methods of problem solving.

Strategy of Leibold [2]	*Strategy of McMaster [3]*
Define the unknown	Definition
Define the system	Scam
List concepts and choose symbols	Planning
Define restraints	Action
Discover the solution	Evaluation
Solve the problem	

Michael Mohr model [4]	*Polya model [1]*
Clarify the purpose	Definition
Development of the idea	Planning
Development of the model	Action
Obtaining the information	Evaluation
Resolution	

Davis [5]	*Rugarcia [6]*
Discovery of data	Detect the problem
Discovery of the problem	Define the problem
Discovery of the idea	Generate solutions
Discovery of the solution	Select solutions
Acceptance of the solution	Check, foresee, implement

One of the methods which have been applied successfully in Mexico is that of Armando Rugarcia [7] and Alejandro Anaya [10] whose strategy indicates that the problem should first be detected (this can be hidden by the large amount of information), then you must set, i.e. identify the unknowns and the objectives of the problem, its restrictions and if it is possible to subdivide it into simpler problems. Then comes the phase of the generation of solutions, creating as many as possible; then you must select one of them, perform calculations, and finally check procedure, the results and the assumptions, analyzing whether or not the answer is logical and if you are in accordance with the previous experiences and the expected orders of magnitude.

But despite everything, interest in problem solving that is manifested by the large number of publications and courses offered on the subject at various universities, there are few textbooks [10, 9] which apply the techniques described by the experts in solving problems.

2. Problems resolution by Stivalet – Valiente method [8]

Despite all the efforts made in different universities, there are few textbooks in which we can see the application of the techniques described by experts in problem solving (Polya, 1957 [1]; Rugarcia, 1988 [7]; Valiente, 1991 [9]; Anaya, 2016 [10]).

This is due to the facts that the techniques described can be used successfully in the classroom, with a teacher who encourages and directs a student that is groping and exploring. In the case of the textbook, the space for discussion and grope is reduced because of the size and cost of the book, so you should use techniques that allow easy monitoring of the procedures employed in the resolution and that accustomed the students to a discipline in the resolution of problems.

For the compression of the behavior of the unit operations, chemical reactor, transport phenomena, physic and chemistry, the students should make numerous problems with balance sheets of matter and energy, with related physical-chemical properties controlling them and with the operating conditions. In addition, you must have in mind that in a book rather than real problems there are exercises where the student applies knowledge, analyzes, synthesizes or evaluates. Of course, in addition to influencing the cognitive area, the exercises affect also the psychomotor area to improve dexterity to calculate, consult tables, graphics and make sketches, diagrams and schemes. The impact on the affective area is affected through the relevance that have the examples and exercises with their social environment. The exercises of end-of-chapter in which student verifies his skill to solve the exercises without outside assistance are also very important so they increase his self-affirmation and appreciation towards the matter.

Here, the author presents a method that has already been applied successfully in classes and in various field related to the teaching of chemical engineering and that he thinks it can be applied with little effort to any matter related to the teaching of chemical engineering.

The problems with which we work are presented in real-world and almost always refer to the needs of producing more and better services and products. However, in order to solve these problems they should be taken from the requirements of the outside world to the world of the mind and there, using mathematics, physics and chemistry, or their combination, they could be answered and then they must be translated back to terms used in the real world (reactants, products, energy, equipment, etc.).

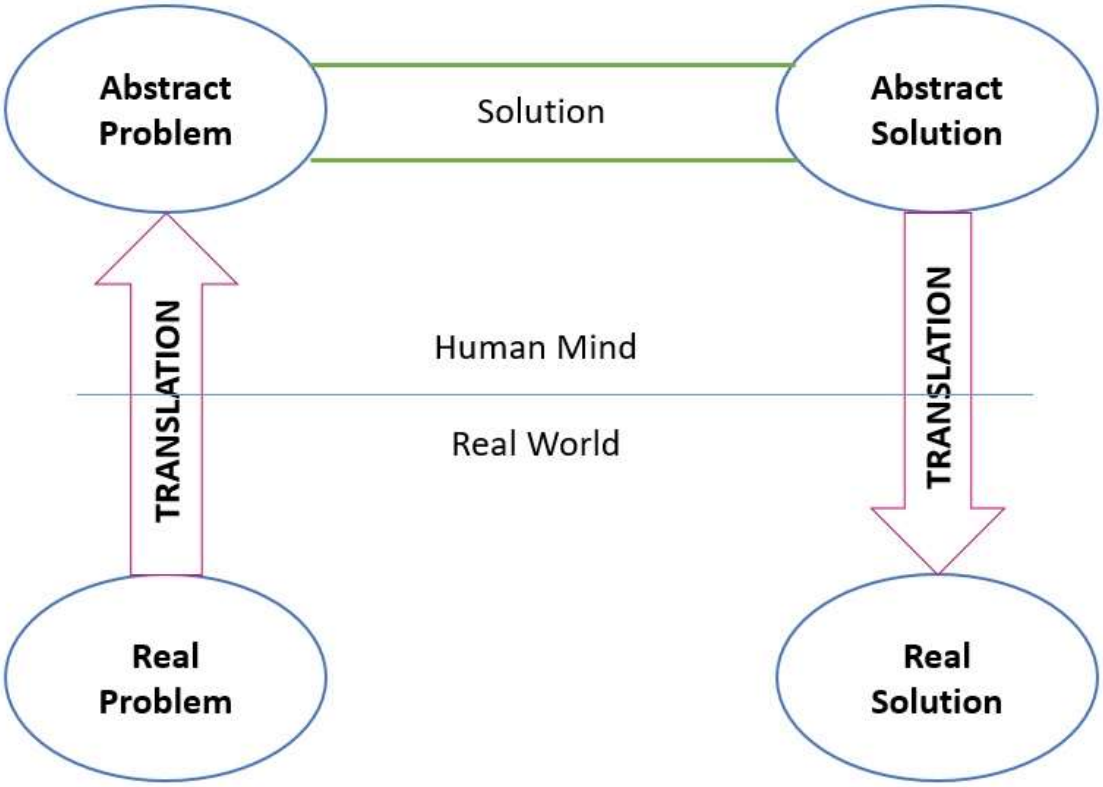


Fig.1 Problem resolution diagram.

In the resolution of problems we can follow a similar sequence. In the first place there will be a statement, which summarizes the requirements of a real problem (in general, to arrive at the drafting of the statement that clearly indicated what is the problem that must be solved, is not an easy task when working in a plant or a design firm).

After the statement, in the first phase of the resolution the statement will be translated into the language used in engineering, i.e., build a flowchart, place the known data on the different lines of input and output and try to represent in mathematical form the question or questions that are expected to be answered by the resolution. Immediately after that comes the resolution using mathematical, physical and chemical knowledge at our fingertips and considering the mathematical equations that lead to resolution. At this stage, it is desirable to prevent the use of numbers and to work with algebraic or differential equations. This stage is equivalent to the generation of algorithms of calculation in a computer. When it has been possible to consider the result in this way, it is easy to replace the algebraic variables by numerical data and get the result, which finally should be translated into the real world, or submitted in written form indicating the results and requirements with words and numbers.

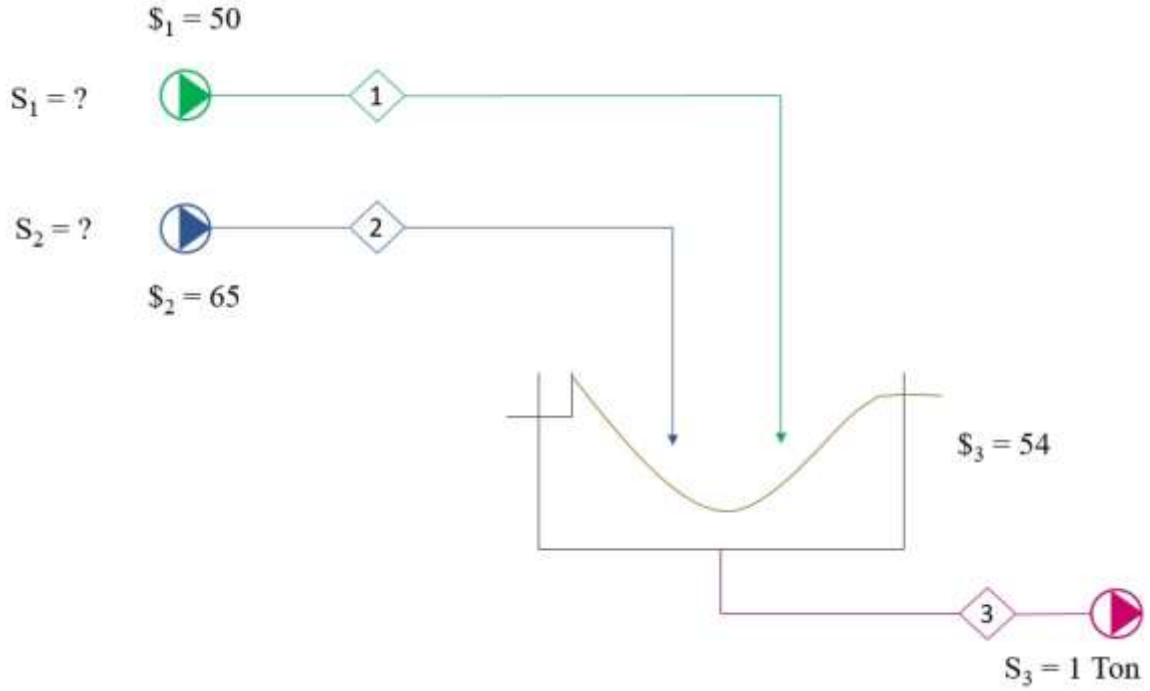
In short, the sequence that the author proposes in this article for the resolution of problems will consist of the following steps:

I. Translation
II. Approach
III. Substitution and calculations
IV. Result

2.1. Application of the method to a problem

There are two types of food for the pigs, one of 50 dollars per ton and the other 65 dollar per ton. To make a mix of one ton at a price of 54 dollars per ton, how many ton of each food should mix?

I. Translation



II. Approach

II.1. Balance sheets of material and costs

$S_1 + S_2 = S_3$

$S_1\ \$_1 + S_2\ \$_2 = S_3\ \$_3$

III. Calculations

III.1. Balance sheets

$S_1 + S_2 = 1$ Ton

$S_1\ (50) + S_2\ (65) = 1\ (54)$

Resolving simultaneously:

$S_1 = 0.733$ ton

$S_2 = 0.267$ ton

IV. Results

0.733 ton from food of 50 dollars and 0.267 ton from food of 65 dollars are required to produce a ton of food for pigs of 54 dollars.

3. CONCLUSIONS

In the engineering courses is necessary to learn the skill or competence to solve problems. Commonly this is learned through the exercises resolved in classes, or by copying the procedures presented in textbooks. This article presents a method that has been used for 30 years both in classes and in the preparation of textbooks and that can implement any teacher or student with few difficulties.

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