Graphical Abstract

Practice shows the way

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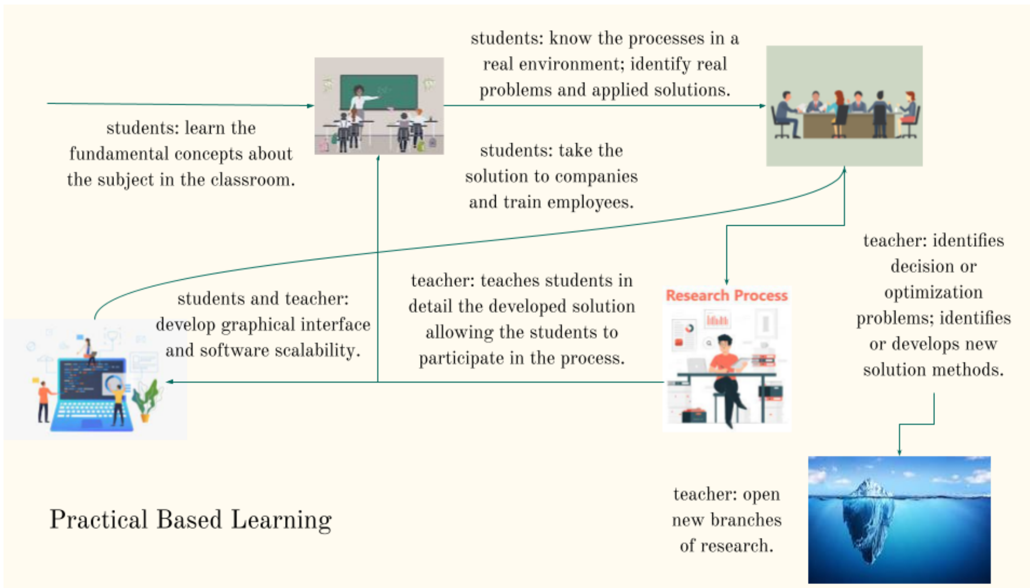

Highlights

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- This paper presents a strategy for teaching undergraduate students based on practical experience
- This strategy is strongly associated with the inseparability between teaching, research, extension and technological development
- This paper also recommends some important resources that can be used to develop group work
- And it discusses a solution to the impasse between transparency and guaranteeing the authenticity of the work, already widely used for software development but not in the development of research works

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Abstract

This paper presents a university teaching strategy, grounded on a practice-based learning approach.

Keywords: practical-based learning

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1. Introduction

Problem-based learning (PBL) is a pedagogical approach applied worldwide, especially in nursing and medicine courses.

2. Practice-based learning

Practice-based learning strategy starts with students learning the basics of some science in the classroom. Concomitantly or after this first learning process, students carry out visits to an organization, through which they will be able to understand organizational processes, identifying aspects of the process that need to be better managed. Students then prepare a report of the visit, describing in detail the process studied and the real problems identified. Subsequently, this information is taken to the Teacher-Facilitator. Through discussions between the teacher and the students involved, the real problems, that is, the aspects of the studied process that need to be improved, are formatted as decision problems or optimization problems. And then a bibliographic survey is carried out on problems close to the identified problem and on methodologies that are applied in the solution of these problems. Then a mathematical model and a solution algorithm are developed for the identified problem and the entire solution developed is passed on to the students, who in turn will take this knowledge to the company. Students will be responsible for carrying out tests to validate the developed solution and for training the company's employees.

For a better understanding of the difference between the real problem identified by the students and the formatted problem, consider the following example: after a student has visited a company that performs the maintenance service of hospital infusion pumps and analyzed in detail the processes of this company, she identified the following real problem:

> "The company is unable to correctly program the hospital pump overhaul service. There are delays in maintenance and services are not prioritized correctly."

After an in-depth study of the company's processes, and extensive discussions between teacher and student, it was identified that the problem was not associated with the maintenance process, but with the scheduling of equipment collection in hospitals, maintenance and return. In this context, a new allocation and routing problem was identified, defined as 'Problem of Planning the Maintenance and Transport of Hospital Infusion Pumps'.

Regarding the bibliographic survey, the teacher must identify the key words as well as what information should be sought in the consulted papers. Then, students will be able to participate in this survey, contributing to the identification of relevant works. Students should also be motivated to translate, read and understand at least one or two papers.

Modeling can be completely performed by the teacher and then explained in detail to the students, or the teacher can explain the modeling process to the students along with some more complex constraints/functions, letting the students participate in this process.

Mathematical Modeling and Optimization are extremely relevant sciences for students in production engineering. Especially when we experience the expansion of Industry 4.0 (Ram, 2021). Through Mathematical Modeling it is possible to accurately understand any industrial or organizational problems in which process optimization is sought and, once a model is built, in order to find the desired answer to the problem, or at least a somewhat close answer, Optimization, and so Programming, simply becomes indispensable. Through my experiences at the university where I work, I developed the following strategy for joint teaching of Mathematical Modeling, Programming and Optimization, combining teaching, extension, research and technology:

Teaching: the fundamentals of mathematical modeling and optimization can be taught to students in two different subjects: 1) Mathematical programming; and 2) Mathematical Modeling. In the first course, modeling mathematical programming problems is taught along with mathematical methods of solution. Modeling problems close to real problems can and should be motivated through case modeling exercises such as those proposed by Hillier and Lieberman (2010). In the second course, students should learn how to model standard optimization problems (e.g. allocation problems; balancing problems; routing problems; and scheduling problems) in addition to some heuristics used to solve such problems. In both courses, students must be motivated to understand and present scientific papers with the modeling of real problems. Extension: the extension applies in four moments: 1) students look for a company to develop their work, know the company, understand the company's operating process, and help to identify optimization problems within the company; 2) an Applied Programming course is offered to students, through which students learn object-oriented programming; 3) the students work with the company in the search for ideas and the refinement of the proposed solution; 4) students take the solution developed for different companies, conducting data collections and testing the solver. Research: once a real problem is identified; it is necessary to carry out a vast bibliographic survey, identifying mathematical models and proposed solution approaches for problems close to the one studied, and it is necessary to develop new solution algorithms, through the adaptation of solutions proposed in the literature. The research must be carried out through research projects, and possibly in parallel with the development of course conclusion works and scientific and technological initiation projects. Technological: once the solution is developed and tested, it is recommended to develop a solver, with a good graphical interface, that can be easily used by company employees. This step can be carried out through technological projects, developed in parallel with graduation projects for students in the technological area, and projects of technological initiation. At this stage, it is also possible to develop partnerships with startup companies, and acquire financial resources to support research and innovation developed within the university. The four lines of action are related as follows: through teaching, students acquire the basic knowledge necessary for the development of research and extension activities; through the extension, students deepen their knowledge of programming, help identify new optimization problem and approaches applied by the company to solve these problems and test the solutions developed, also qualifying company employees; through research, students participate in the development of solutions to identified problems; and through technological projects, students can participate in software development. Both research and extension works contribute to teaching, as they allow students to understand and expand all the content presented in the classroom, through practice. It is important to emphasize that throughout the process, students must work together with teachers who have extensive knowledge and practice regarding the subjects covered. So, the teachers involved also deepen their knowledge, which significantly improves the quality of teaching.

References

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