IMPROVING ENGINEERING LABORATORY ACTIVITIES THROUGH EFFECTIVE MANAGEMENT METHODS

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ABSTRACT: The training of future engineers is based on theoretical elements discovered with enthusiasm by true visionaries and inventors throughout human history. However, both in the past, when the greatest technical discoveries were made, and today, when the trend is towards maximum use of artificial intelligence, and even more so in the future, practical activities have represented, represent and will represent the key to success in the training of engineering students. This paper highlights several problems faced by students of an engineering faculty in Romania during laboratory activities, as well as several specific methods of quality management and creativity management that can help the teacher in reducing or even eliminating these problems. The case studies presented in the paper are each based on the application of an established management method, which leads to the improvement of laboratory activities for the discipline in which it was used.

KEY WORDS: management, method, engineering, laboratory, activities.

1. INTRODUCTION

Specialists say that a practical laboratory with up-to-date instruments is a means of improving students' motivation to study engineering [5]. However, the modern equipment of a laboratory is not the only factor that leads to achieving the laboratory objectives established by the teacher for the respective subject. The teaching staff must also focus on creating and using real or virtual models in the laboratory, on developing students' skills in collecting, processing and interpreting data and information, but also on instilling in students' minds the idea of designing and developing products that meet customer requirements [4, 5].

For example, the case studies in this paper were conducted in disciplines that require high-performance computing and software rather than machine tools, manufacturing lines, or other production equipment. To improve student results in these laboratory activities, the academics and students applied improvement methods specific to quality and creativity management, methods that revealed numerous other factors that must be taken into account when solving laboratory problems.

2. THEORETICAL PREMISES OF THE RESEARCH

Teachers increasingly want engineering labs to emphasize creativity [3, 5, 8]. Therefore, the laboratories are meant to develop both the practical skills of future engineers, as well as their creativity. The emphasis that teachers place on student teamwork is another relevant aspect of engineering labs [5, 6]. Thus, the laboratories will also develop students' group creativity, which will benefit the companies where they will work after completing their studies. Teamwork, according to specialists, also increases communication skills and develops students' conflict resolution skills [7].

3. METHODS FOR IMPROVING LABORATORY ACTIVITIES

We selected two case studies on the application of management methods to improve laboratory activities in two subjects taught for different specializations at the Faculty of Engineering of the "Lucian Blaga" University in Sibiu (LBUS), Romania, namely:

- Production and Service Management (PSM) for Economic Engineering in Mechanical Field specialization, with distance learning;
- Industrial Logistics for Mechatronics and Robotics specializations.

3.1. The first case study, based on problem tree method

Remote learning at LBUS faces numerous challenges, especially in the field of engineering studies. Our first case study is based on the activities carried out at the PSM laboratories and on the project hours within the Economic Engineering in Mechanical Field specialization, with distance learning. The regulations of the university and the Faculty of Engineering require students to complete all laboratory and project activities in order to be able to participate in the final exam of the discipline. The standards in force provide that laboratory activities, practical work, project, and practice for distance learning "are organized face-to-face on the university campus/online synchronously in groups/subgroups" ([1], p. 11).

Considering that most of the course hours and applications in distance engineering education take place in Romania with the physical presence of students in classrooms, most of these activities are scheduled in LBUS on Saturdays and Sundays. The labs and projects are extremely demanding for students in these conditions and some of them fail to complete all laboratory/project tasks. Even if distance learning students are physically present for all applications according to the schedule, they must subsequently complete certain laboratory or project work requirements at home. Compared to those enrolled in full-time education, many more distance learning students face the problems summarized in Table 1.

Table 1. Main problems in laboratory and project activities of distance learning engineering students

No.	Problem	Frequency (*f*)	Severity (*s*)	Score (*f* • *s*)	Ranking
1	Failure to complete all laboratory/ project tasks	4	5	20	I
2	Poor communication with colleagues	3	2	6	IV
3	Conflicts in the student team	1	3	3	V
4	Numerous errors in reports	3	4	12	II
5	The mistaken impression of the discrepancy between theory and practice	3	3	9	III

To rank these problems, we used for frequency (*f*) and severity (*s*) the evaluation scale: 1 point (for a very rarely encountered problem, respectively of very low severity), 2, 3, 4, and 5 points (for the most common problem, respectively the one with very high severity). We conducted the evaluation according to the results observed in practical activities at PSM over the last five academic years. First place is occupied by the failure to complete laboratory/project work, a problem that we have already analyzed with the problem tree method (Fig. 1).

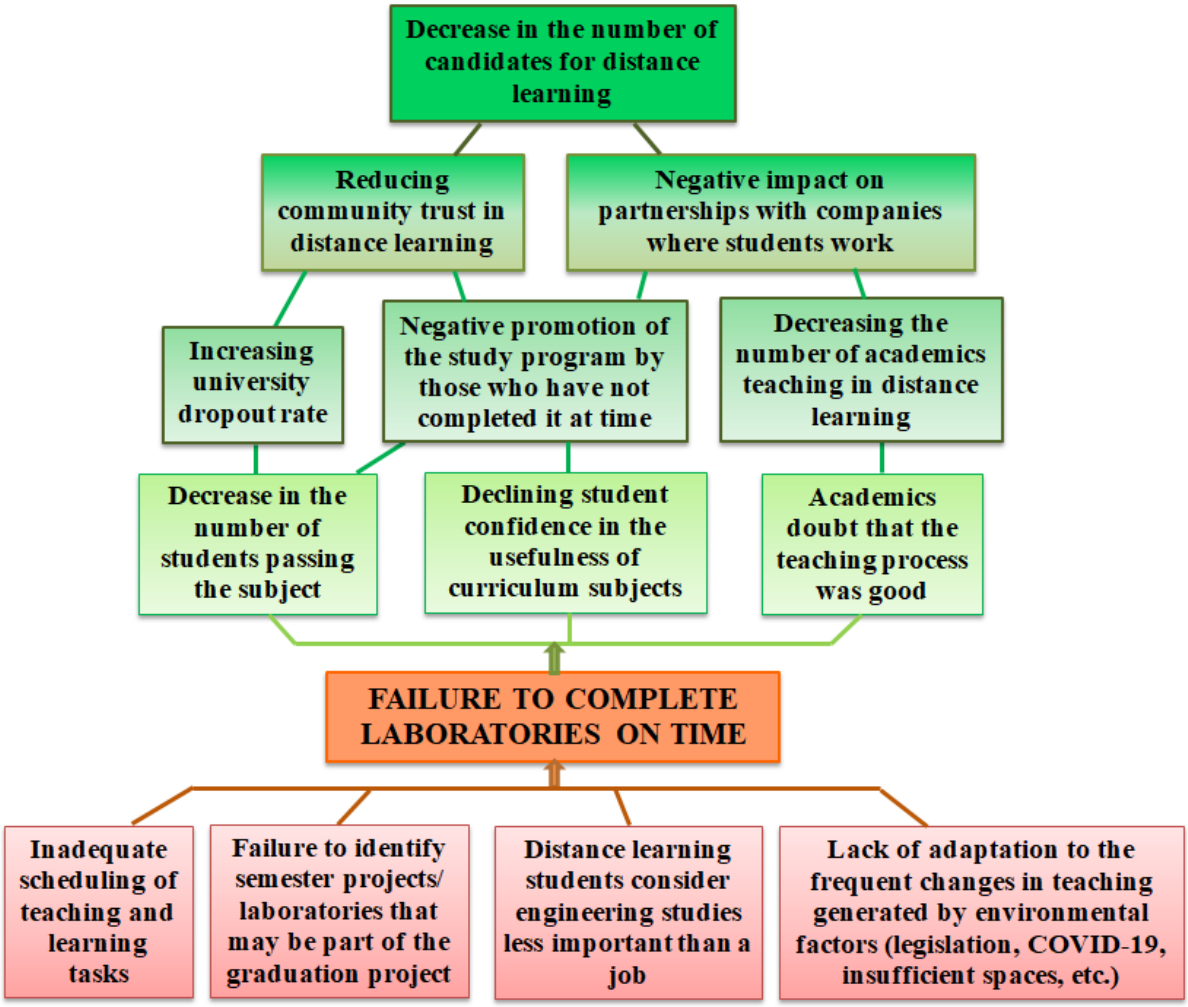

Figure 1. The problem tree method applied to solve the main problem in the PSM laboratory for distance learning: failure of students to complete labs on time

With the help of this tree, but also after consulting with colleagues who teach the same subject and with students from the mentioned engineering specialization, we found some important solutions to solve the main problem in the PSM laboratories:

- Distance learning students must be convinced to go through the theoretical material indicated by the teacher before taking the labs;
- The teacher should allocate approximately 5-10 minutes of each laboratory to exemplify the use of the respective work in graduation projects from previous years;
- The teacher will adapt (from one academic year to another) to each student promotion, but will maintain or increase the requirements from previous years regarding laboratory activities;
- Establishing a different order of laboratories from year to year, depending on the entire program of the respective group, respectively the demands to which students are subjected on Saturday and Sunday in laboratories and projects of other disciplines;
- Convincing everyone involved in the educational process that distance learning is a solution of the future, designed to demonstrate a university's ability to train specialists beyond geographical boundaries.

3.2. The second case study, based on 5W and 1H method

Keeping laboratories updated, fresh from year to year, is absolutely necessary due to the change of conceptions and personalities of new batches of students. And yet there are specializations where students from one series seem to hand over a "relay race of values" to the next series. This is mainly about final year students from top engineering majors. Both the values of the teachers who trained them and their passion for engineering led to the formation of this habit.

This is also the situation of final-year students from the Mechatronics and Robotics specializations of the Faculty of Engineering in Sibiu.

For the teacher, the Industrial Logistics laboratories in these specializations were a permanent challenge for improvement. From year to year, other problems appeared in these laboratories, most of them student- or group-centered. Here are a few examples:

- The great efforts of some students employed in companies to attend classes (lack of time, frequent trips from university to work and vice versa etc.);
- The existence of students who do not have personal computing equipment (laptops) and cannot complete their homework outside of the faculty;
- Difficulty understanding, by some students, of applications based more on the analysis of elements of the industrial environment than on the application of a known mathematical tool;

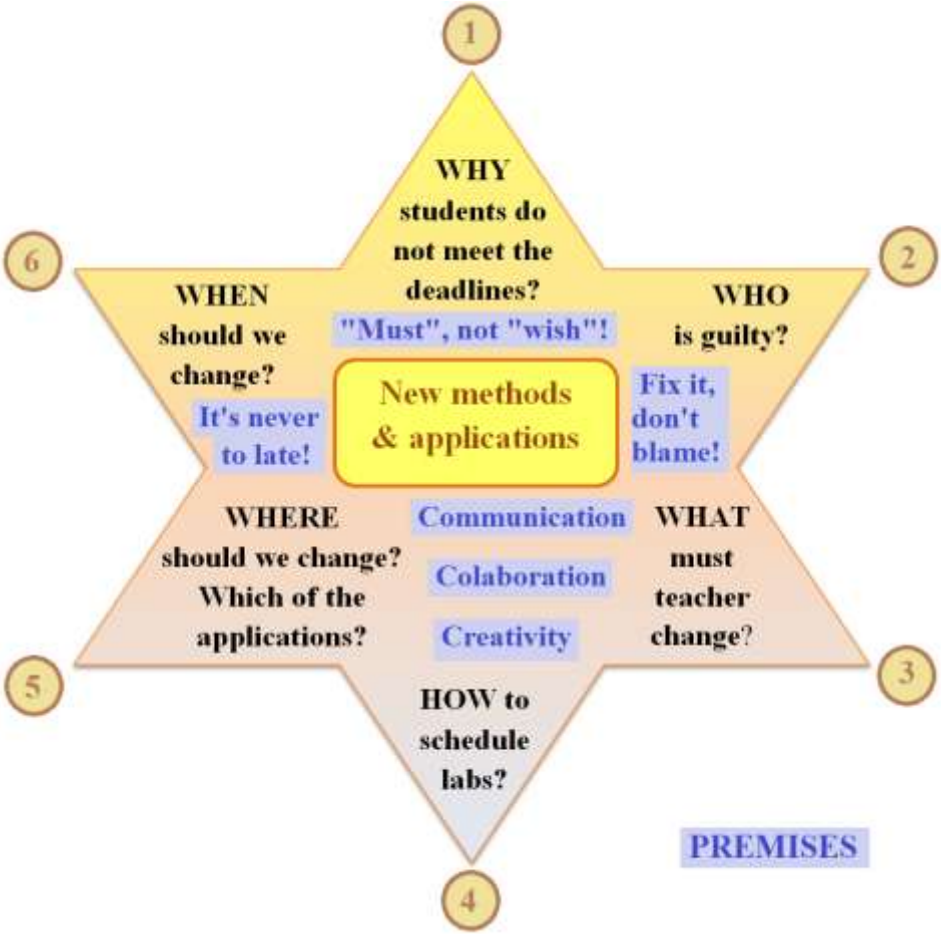

Figure 2. Applying the 5W and 1H method to increase the efficiency of training in Industrial Logistics laboratories for Mechatronics and Robotics students

- Schedule changes due to visits by authorities that accredit the respective specializations (an additional stress factor) or to national and international Robotics competitions.

The severity of these problems was quite small, but they could every year be combined into one: although the efficiency of training in these laboratories is very good, it can still be increased. To achieve this, we used the 5W and 1H method (Fig. 2). The application of the method with Mechatronics and Robotics students had several premises - highlighted in Figure 2 - through which the teacher imposed rules aimed at increasing students' self-confidence, the frequency and efficiency of communication, as well as their individual and group creativity.

We recall the most important solutions discovered together with the students:

- The need to introduce as many applications based on mathematical tools as possible to the laboratory, because future engineers have a real affinity for technology;
- Permission granted to students to choose their preferred software for solving laboratory problems, even if it was not studied within the faculty;
- Introducing blended learning and encouraging students to use the internet to find the information necessary to solve laboratory tasks;
- The use of mobile learning combined with team game elements, which has also yielded results in laboratory activities in other universities [2];
- Encouraging face-to-face and online communication within the student group, while varying the tasks and numerical values of a problem from student to student; when they benefit from the advice of their colleagues, but cannot copy their solutions, not having identical tasks to them, the laboratory challenges seem easier;
- Adapting the time allocated to different laboratory tasks according to the needs of each group of students, as one group needs more explanations for one type of problem, and another group for another type.

4. CONCLUSIONS

Engineering teachers and students have not to forget that "quality starts with customers and is defined by customers" [4]. All training activities for future engineers - courses, seminars, projects, laboratories - should be centered on this concept.

From one year to the next, new challenges arise in engineering laboratory activities. The skills, mindset, and preferences of engineering students differ from one group to another. For laboratory activities to become sustainable, teachers must not only focus on the issue of costs and the renewal of laboratory equipment. Academics must understand and take into account students' desire for professional development, despite the personal problems they face daily.

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