IMPLEMENTATION OF A SCHOOL OF TRAINERS FOR THE INTEGRATION OF ACTIVE PEDAGOGICAL STRATEGIES IN PHYSICS LABORATORIES

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Abstract

The School of Physics of the Faculty of Sciences at the Universidad Industrial de Santander-UIS (Santander-Colombia) started in 2015; a project aimed at encouraging students to achieve research skills. Students enrolled in the programs of the Faculties of Sciences and Engineering, which within their curriculum have established the courses of Physics I, Physics II, and Physics III, as well as undergraduate students in Physics who take Mechanics, Electromagnetism, Mechanics II, Waves and Particles, and Modern and Optical Physics classes, are enrolled in the project.

This proposal of improvement comes from the idea of the laboratory as an experimentation space, which makes sense in the framework of a research project. This idea materialized in a didactic form through the integration of the active learning strategies Just-in-Time Teaching (JiTT) and Mediated Learning (ML). The proposed didactic strategy involves a learning sequence that begins with the familiarization of the research project material followed by assessment through a Laboratory Preparation Questionnaire. After the Laboratory session was carried on, the students write down a report with their findings and results. The activity ends with the teacher's evaluation and feedback on the report.

The project was implemented in 2015 with a group of 5 teachers and 560 students, but there was a disparity in the application of the established guidelines of the educational strategy, both little motivation and broad criticism of the process from the involved teachers. To overcome these disadvantages, in 2016, the School of Trainers was organized, which focuses on providing pedagogical, didactic, and practical techniques to the teachers who will implement the improvement proposal to facilitate their work developing the subjects involved, aiming to strengthen the School of Physics processes, and to contribute to the academic improvement of the students who are part of them.

The School of Trainers organizes its process based on the same didactic strategy that involves reading material support, session preparation questions, skills development through active and mediated learning strategies, the perception of the process by the teachers and students, and feedback on the findings obtained in the perception to the collective.

This article describes the implementation process of the School of Trainers for the teachers of Physics Laboratory 1, 2, and 3, developed during the first and second semester of 2016, in which 17 teachers have been trained. It identifies important aspects for the acceptance of the didactic strategy by the teachers, such as: 1) taking into account previous experiences in teaching physics laboratories and highlighting the aspects included in the pedagogical proposal to facilitate the learning of the students; 2) provide constant feedback for the use of the linked Moodle course, in order for them to overcome the technical difficulties using the technology; 3) reaching agreements with the teachers on how to evaluate and to create the tools to assess such evaluation; 4) generating participatory dynamics for the construction and revision of the didactic material that supports learning in laboratories.

Keywords: training of trainers, active learning, JiTT, mediated learning, physics laboratory.

1 INTRODUCTION

In the last two decades, higher education has driven constant changes focused on developing in students the skills needed in the context of the knowledge society, to move towards a comprehensive training approach that promotes competencies for life and encompasses multiple dimensions of knowledge [1]. This demands the transformation of teaching practices [2], the incorporation of
technologies for learning, and the definition of new forms of educational management based on evidence [3].

Within governmental initiatives focused on this transformation includes the formulation within the Ministry of National Education of Colombia - a framework of generic skills for higher education, the constant review of state tests for graduation students. In educational management, the organization of processes of qualified registration of academic programs, the requirement of self-evaluation and high-quality accreditation processes for programs and institutions.

One of the most complex skills to develop in undergraduate students is the skill for research [4], starting from the concept that research as a reflexive, systematic, controlled, and critical procedure whose purpose is to discover, explain, or interpret the facts, processes, relationships and constant generalizations that occur in a given context [5]. The achievement of research skills involves strengthening the processes to observe, ask, experiment, data analysis, interpret information, teamwork, use technology, and write reports to systematize the actions performed in research, in addition to publish and manage knowledge [6]. Several authors have designed educational experiences of different trends for science education, including the use of the inductive method, which includes strategies such as discovery learning, based on research [7], based on solving problems [8], project-based [9], case-based, and just-in-time teaching (JiT) [10].

The need for a research training strategy in the Universidad Industrial de Santander (UIS) was evident at 2013 because the self-assessment process performed at institutional accreditation shows the research training given to bachelor students as the lowest indicator in all the self-assessment process [11]. For this reason, the School of Physics and the Dean of Sciences propose, in 2015, the execution of a project focused on the development of research competencies, through the implementation of a didactic strategy that integrates 3 theoretical aspects: active learning, mediated learning, and JiTT.

Active learning is a teaching and learning strategy, which involves the student in activities such as reading, writing, discussion, or problem-solving to promote the analysis, synthesis, and evaluation of the class themes [12]. Active learning requires that students engage in meaningful learning activities and think about what they are doing [13]. Active learning is in opposition to traditional learning, which is expressed in strategies that privilege teacher's exposition.

Just-in-time teaching is a teaching and learning strategy that promotes the use of time in the classroom more actively. This strategy, designed by [10] and his colleagues in the Study Group on Conditions of Excellence in American Higher Education, defines a feedback loop between a student's study of a set of web resources and the classroom class [14]. At JiTT, students prepare their class by completing a set of online assignments, which are reviewed by the teacher to tailor lessons according to student prescriptions and learning objectives. JiTT defines some types of exercises that focus on getting students to the prepared, engaged, and motivated classroom sessions: WarmUps are short assignments delivered via the web, designed for students to perform before class on a topic; Puzzles are short assignments that help structure knowledge about a topic that has already been covered in class, and; GoodFors are enriched essays to help students connect the class to the real world. According to [15], the JiTT incorporates 3 aspects to help students in their learning: 1) a focus on active learning, 2) structured opportunities for students to actively build new knowledge from their pres- And 3) provides effective feedback to the student [14].

Mediated learning emphasizes the design of mediated learning experiences, which are defined as a quality of the interaction of the organism with its environment through a human mediator [16]. In the case of the educational process, the teacher is the mediator, who interposes between the stimuli that the student receives from the environment and directs them appropriately to achieve the expected learning goals. The experiences of mediated learning aim to respond to several of the problems that the current educational system experiences: the rapid changes in knowledge and technologies that demand greater flexibility of students to learn the new, this implies focusing on the process to learn, more than knowledge itself. The social demand for education so that the formative spaces are areas of inclusion, which implies the recognition of the particular needs of the students and the opportunity to access resources according to the differential characteristics, according to the evident multiculturalism in the academic spaces [17].

The proposed didactic strategy involves a learning sequence that begins with the familiarization of the research project material, and this includes documents and videos; followed by assessment through a Laboratory Preparation Questionnaire. After the laboratory session begins, the students write down a report with their findings and results. The activity ends with the teacher's evaluation and feedback of the report [18]. Figure 1 illustrates the didactic strategy that is executed for each of the laboratories.
In 2015, the first application of the didactic strategy was carried out with 5 professors and 560 students of Physics Laboratory I. The results showed a disparity in the application of the proposal, originated in a low motivation and widespread criticism to the proposed guidelines by teachers, demonstrating a preference for traditional practices. To overcome these disadvantages, in 2016, the School of Trainers was organized, which focuses on providing pedagogical, didactic, and practical techniques to the teachers who will implement the improvement proposal to facilitate their work developing the subjects involved, aiming to strengthen the School of Physics processes, and to contribute to the academic improvement of the students who are part of them.

The School of Trainers organizes its process based on the same didactic strategy that involves reading material support, session preparation questions, skills development through active and mediated learning strategies, the perception of the process by the teachers and students, and feedback on the findings obtained in the perception to the collective. Figure 2 shows the complete cycle of the didactic strategy used in the development of the School of Trainers. The idea of the School of Trainers (SoT) is to provide tools and encourage collective agreements, to improve the implementation of the didactic strategy of physics labs with students. The skills developed by SoT are:

- It understands the principles of active learning, Just-in-Time Teaching (JiTT), and mediated learning. Also, their characteristics, and the way they are integrated into the development of the methodological proposal of the School of Physics.
- It develops the stages of the didactic strategy proposed by the School of Physics with a view to achieving the development of student research skills.
- It manages collaborative learning processes, to facilitate the interaction in the work groups of the students and the achievement of the proposed competences.
- It participates actively and collaboratively in the discussions on the pedagogical, didactic, and practical aspects required for the development of the educational strategy in the subjects of the School of Physics.
The SoT has been implemented during the first and second semester of 2016 with 17 teachers from Physics Laboratories I, II, and III and is the strategy defined for the consolidation of the didactic strategy. In each of the cohorts of the School of Trainers, the results obtained are reviewed, and improvements are proposed to achieve the training goals, both from the appropriation of the didactic strategy and the development of research skills by the students.

2 METHODOLOGY

The implementation of the School of trainers is guided by the qualitative research approach, with a case study design, based on two cohorts; 2016-I and 2016-II. The experience was carried out in two cohorts:

- 2016-I participated 10 teachers and involved 1054 students in Physics Laboratories I and II.
- 2016-II participated 7 teachers and involved 1629 students in Physics Laboratories I, II, and III.

The implementation was supported in a virtual Moodle classroom for the organization of resources and the execution of the session preparation questionnaires - CPS, as well as a Google Drive form for collecting the perception information of teachers and students. Also, face-to-face sessions were held in which collaborative work was encouraged. The perception survey was answered by 59% of the students enrolled in 2016-I and 29% of the students enrolled in 2016-II.

In both cohorts, the teachers developed at least 3 complete laboratories, following the defined didactic strategy strictly. Physics laboratory teachers are mostly part-time teachers, with an average age of 25, and they are studying master's degrees.

3 RESULTS

3.1 2016-I

In this cohort, the initial face-to-face work was oriented to the identification of the main problems in the development of the Physics Laboratories through the implementation of group brainstorming whose
results were specified in a fishbone chart. Each group of teachers approached the specification of the main branch. The main branches address the aspects related to:

- Students and Group
- Equipment
- Laboratory classrooms
- Laboratory methodology
- Guides and Resources
- Procedures
- Data collection
- Report

The branches corresponding to Students and Group & Laboratory Methodology present a greater number of aspects identified within the analysis. Table 1 shows the aspects in these branches.

Then alternatives of solution were identified by the teachers' group, which were organized in a chart classified by the ease of implementation and by the impact on the problem. Figure 3 shows the matrix used for the classification of solutions.

<table>
<thead>
<tr>
<th>Branch</th>
<th>Problem traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students and groups</td>
<td>Pre-know students</td>
</tr>
<tr>
<td></td>
<td>Low autonomy of students</td>
</tr>
<tr>
<td></td>
<td>High number of students per group</td>
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<tr>
<td></td>
<td>Lack of knowledge of equipment</td>
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<tr>
<td></td>
<td>Non-homogeneous and motivated groups</td>
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<tr>
<td></td>
<td>Culture related to the master class</td>
</tr>
<tr>
<td></td>
<td>Low preparation of practices</td>
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<tr>
<td></td>
<td>There is no teamwork.</td>
</tr>
<tr>
<td>Laboratory methodology</td>
<td>Not clear for students</td>
</tr>
<tr>
<td></td>
<td>No instructions from the equipment</td>
</tr>
<tr>
<td></td>
<td>Proper use of the introductory session.</td>
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<tr>
<td></td>
<td>Understanding the intentionality of the laboratory</td>
</tr>
<tr>
<td></td>
<td>CPL does not involve procedures and equipment</td>
</tr>
</tbody>
</table>

Then, alternatives of solution were identified by the teachers' group, which were organized in a chart classified by the ease of implementation and by the impact on the problem. Figure 3 shows the matrix used for the classification of solutions.

The proposals that identified the easiest implementation and high impact were:

- Preparation and accompaniment of the teacher.
- Teaching and auxiliary training on equipment management.
- Improve the procedure and documentation of equipment in the guides.
- Improve video editing.
- Integrate theory with the laboratory.
- Instruction of statistical analysis.
The proposals that were identified as the most difficult to implement and high impact were:

- Maintenance program
- An increase in the percentage of laboratories, considering that this would increase the motivation.
- Student attention space for part-time teachers.
- Review of research projects
- Organize resources for the presentation of the didactic strategy.

3.1.1 Collective agreements

In the first cohort of the SoT, a template for the organization of research reports was obtained so that students can be guided on the aspects to be included and their characteristics. The reports presented by the teachers in the execution of the laboratories during the SoT were used for the identification of the template components.

3.1.2 Teachers’ Perception

Despite the works done in the SoT, teachers do not appreciate the differences between the results obtained with the proposed didactic strategy, with respect to the strategies that were used previously for the development of physics laboratories. Some comments that contribute to the improvement are:

- Continue implementing it until the success of this method reaches 100%.
- Improve research projects, especially in relation to the data processing and theoretical basis.
- I would add the assistance option.
- To increase the question bank, by socializing between the teachers and the teachers who administer the platform.
- To improve the resources and the components in a virtual classroom.

Another element to consider is the disparity of parameters and points of view that are applied in the evaluation of research reports. The group at the final meeting raised the need to define an instrument to facilitate the application of unified criteria in this evaluation.

3.1.3 Students’ perception

One of the most important findings in the student survey is the periodicity with which teachers provide feedback to students about their work. 42% stated that they received feedback every 15 days, which corresponds to the desired dynamic, while only 12% said that teachers communicated notes at the end of the semester. In the previous methodology, a frequent complaint of the students is that they only received the final grade of the course at the end of the semester, which did not allow improvement options for the students in the following experiences.

Other perception data are:
53% said that the virtual classroom seemed Good and 28% Excellent, and only 7% think it is Bad.

64% said that the resources provided were sufficient to carry out the experimental test and 36% considered them insufficient.

About the lab methodology, 47% said that it takes between 1 and 3 hours to prepare the research projects of the laboratory and 29% that devote between 3 and 5 hours.

85% perceived that it is easy to perform the experimental part and 63% stated that after passing the experimental part, they could carry out the investigation reports clearly.

74% considered the resources provided in the virtual classroom to be appropriate.

56% believed that the experience in the laboratories contributes to their professional training to a high degree and 36%, in the middle grade, considered that the students perceive in a positive way the experience with the new didactic strategy.

3.2 2016-II

The second cohort of the SoT was made by the teachers who entered the group of Laboratory Teachers. This time, the problem identification exercises were not carried out, since most of the aspects that were found there had already been improved during the semester. The didactic strategy was implemented with all laboratories (Physics I, II, and III), but only 29% of the students answered the perception survey.

Instead, the face-to-face sessions focused on deepening the pedagogical references and the execution of the laboratories, in order to facilitate the revision and enhance the different available resources (research projects, videos, data sheets, CPL questions, etc.).

3.2.1 Collective agreements

The main collective agreement that was obtained in this cohort was the organization of an evaluation rubric. This rubric defines a set of aspects to evaluate with their corresponding percentages. This allows unifying the criteria in the evaluation process of the research reports.

3.2.2 Teachers Perception

On this occasion, teachers’ perceptions of the process improved, as 41% selected students to be interested in the development of the practices and 16% perceived that students were proactive in the experimental verification of theoretical concepts.

Among the identified drawbacks are:

- The students do not know about the statistical data treatment.
- Sometimes, they do not read the research projects in detail, so they have problems with the handling of the data at the time of the reports.
- Some CPL are not according to the course.
- The students do not recognize the project to prepare; nevertheless, they read the two projects, realize the two CPL, and justify not understanding the use of the platform.
- Problems in the theoretical bases.
- The methodology proposed in the guidelines is not explicit.
- Difference between theoretical development and the laboratory.
- Lack of interest in the laboratory. They listen, but do not put anything into practice.
- The students do not study for lab work.

With regard to the feedback frequency of CPLs and reports, 83% are reported to feedback CPLs every 15 days and 58% to disclose reports every 15 days. In this aspect, we expect all teachers to provide feedback every 15 days, both CPL and research reports, but it is necessary to motivate teachers.
3.2.3 Students’ perception

With regard to the feedback frequency of CPLs and reports, it is observed that 71% feedback the CPL every 15 days and 85% feedback every 15 days reports. This corresponds to a significant improvement in the compliance of this aspect by the teachers.

Other data compiled show:

- 49% of students think that using the virtual classroom is Good and 17% believe it is Excellent, while 10% believe it is Bad. In this, indicator decreased the perception of Excellent.
- 61% said that the resources provided were sufficient to carry out the experimental test and 39% considered them insufficient.
- 44% qualify as easy and 11% as very easy, the execution of the experimental component.
- 49% qualify as Acceptable the difficulty of writing the research report, 23% perceive that it is Difficult, and 6% that it is Very difficult.
- 56% rated the laboratory experience with 4/5, 23% rated it 3/5 and 15% rated it 5/5. The average rating is 3.78.
- 27% believe that the experience in the laboratories contributes to their professional training to a high degree and 57%, in the middle grade, consider that the students perceive in a positive way the experience with the new didactic strategy, but there was a decrease for this item.

4 CONCLUSIONS

The exercise of the SoT with the Physics Laboratory teachers of the Universidad Industrial de Santander shows that there are some aspects that must be maintained in the design of the training: 1) taking into account previous experiences in teaching physics laboratories and highlighting the aspects included in the pedagogical proposal to facilitate the learning of the students, 2) provide constant feedback for the use of the linked Moodle course, in order for them to overcome the technical difficulties using the technology, 3) reaching agreements with teachers on how to evaluate and create the tools to carry out such an evaluation is not enough, it is necessary that there's a constant motivation exercise for their use by teachers, because even if they have the tools, they are not used properly, 4) generating participatory dynamics for the construction and revision of the didactic material that supports learning in laboratories, 5) it is necessary to adjust the activities of the SoT to overcome the deficiencies found in the implementation. In addition to continuing with the teachers who have already done it, because their experience is fundamental to the achievement of the methodological appropriation.

It is important to obtain the students’ perception and contributions to continue in the process of continuous improvement of the proposal.

Future studies aim to investigate the impact on the development of student research skills, in order to evaluate the effectiveness of the didactic strategy.

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