Laboratory preparation questionnaires as a tool for the implementation of the Just in Time Teaching in the Physics I laboratories: Research training

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Abstract.

The implementation of the JiTT (Just in Time Teaching) strategy is presented to increase the previous preparation of students enrolled in the subject Physics Laboratory I offered at the Industrial University of Santander (UIS), Colombia. In this study, a laboratory preparation questionnaire (CPL) was applied as a tool for the implementation of JiTT combined with elements of mediated learning. It was found that the CPL allows to improve the students’ experience regarding the preparation of the laboratory and the development of the experimental session. These questionnaires were implemented in an academic manager (Moodle) and a web application (lab.ciencias.uis.edu.co) was used to publish the contents essential for the preparation of the student before each practical session. The most significant result was that the students performed the experimental session with the basic knowledge to improve their learning experience.

1. Introduction

In the last years, the university education system has presented a change in its politics restructuring the traditional approach based on the passive transmission of knowledge, to move towards a comprehensive training approach that promotes competencies for life and contains multiple dimensions of knowledge [1]. In the year 2008, the Ministry of National Education of Colombia formulated the generic competences in higher education institutions.

For this reason, educations institutions have sought to incorporate Information and Communication Technologies (ICTs) into teaching-learning processes to improve the quality of teaching. However, despite the increased availability of technological resources in educational establishments, also, it has been shown that several teaching practices with ICT resources do not represent an advance, innovation or improvement of the traditional practices [2].

Several authors have reported their experiences with different pedagogical models for teaching science, one of which are inductive methods that include discovery-based, research-based, problem-based, project-based, case-based, and Teaching at the time, Just in Time Teaching (JiTT) [3, 4, 5]. A particular case of study is the JiTT proposed by Professor Gregor Novak. JiTT uses active learning and ICTs as the principal elements of the teaching strategy. Using this approach, Professor Novak observed a real change in the student’s interest in learning physics [6] with a 40% reduction in students drop out in comparison with traditional methodologies.
This strategy has also been implemented for the teaching of sciences such as chemistry, mathematics, economy, among others [8, 9].

The need for a research training strategy in the "Universidad Industrial de Santander" (UIS) was evident at 2013 because the self-assessment process performed to institutional accreditation. This process has shown the research training, given to bachelor students, as the lowest indicator in all the auto-evaluation process [10]. Another important factor that motivated the change in didactic strategy was the high index of desertion in the first levels. The development of investigative competencies implies the strengthening of skills to observe, ask experiment, interpret information, teamwork, appropriate use of technology, write reporting, order and systematize the investigative actions, publication, and knowledge management [11]. Because of this the Academic Vicerrectory, the Sciences Deanship and mainly the Physics School at UIS proposed a project in the year 2015 to improve the research training, with the objective to improve the education quality.

This study has the objective of innovating teaching and learning processes for the students enrolled in the Science and Engineering faculty programs through the Just in Time Teaching (JiTT) methodology to research training throw. The project started in the second academic semester of 2015 with the enrolment of all Physics I laboratory classes [12]. The methodology implemented encompasses three pedagogical strategies: active learning, mediated learning and just in time teaching in physics laboratories. In this paper, we describe the second implementation and some results of such strategies in the first semester of 2016.

2. Methodology
The implementation in the first academical semester of 2016 included 11 teachers and all the students taking Physics I laboratory class. Approximately 88% of the population (352 students) taking the class were surveyed. The Physics I laboratory course has a theoretical and an experimental component. Independent programs and teachers handle each of this components. The signature corresponds to the 20% of the class grading. This signature is graded as follows:

| Component                                      | Percentage |
|------------------------------------------------|------------|
| Laboratory Preparation Questionnaires (CPL)   | 30%        |
| Laboratory Reports (I)                        | 40%        |
| Final Project (Ω)                              | 30%        |

The methodology consists of two parts, first out of the class (didactic) and second in the class.

2.1. Didactic or out of the class component
To prepare the practical sessions, a set of laboratory preparation questionnaires (CPL) were proposed to the students, where the JiTT strategy and mediated learning elements were implemented, all of this via the Moodle platform (tic.uis.edu.co) and the web app lab.ciencias.uis.edu.co for the content management. The CPL are a new tool that mixes the JiTT strategy with mediated learning based on ICTs. The JiTT consists of asking open questions to motivate student introspection. The mediated learning component consists of closed (mediation) questions related to the preparation of the laboratory. The mediation (closed)
questions focus on the most important aspects to be taught during the lab while the JiTT questions aim at the identification of student argumentation. In particular, the closed questions were focused on equipment utilization and basic theoretical concepts and the JiTT questions in the experimental methodology to be implemented in the laboratory room. For the preparation of a practical session, each student was asked to review the published material in the web platform, which included projects, videos, equipment usage tutorials, and methodology related to the experiments carried out in the particular laboratory. The CPL were available 36 hours before the lab class in agreement with JiTT. The Moodle platform automatically graded the closed questions, and the teacher reviewed the JiTT questions.

2.2. In the class component
Based on the results of the out of the class component, the professor, at the beginning of the lessons, reinforced theoretical concepts that were found not to be adequately understood by the students, as the JiTT suggest. Following, the students proceed with the experiments more quickly given the previously (out of class) review of lab equipment, procedures, methodology, and other skill to perform their laboratory practice.

3. Measurement tool
At the end of the semester, an anonymous on-line survey for the students and professors was used to evaluate the impact of the strategies implementation.

Figure 1. Summary of the question: Do you consider appropriate research projects?

Figure 2. Summary of the question: How would you rank the use of Moodle platform in the laboratory?

3.1. Results
The survey at the end of the semester attended two purposes: first, to evaluate the student’s acceptation level of the proposed methodology and second, to determine the improvement of the research training. The sample consisted of 88% of all the students taking the class and all the professors during this period. The results, collected via the Moodle platform, shown an improvement in the research training in the sense that student considered appropriated the research projects (figure 1) and the comments of the teachers with more than two years imparting the course. The acceptation of the methodology was very confident (figure 2). 91.8% of the students thought the platform useful for the strengthen of their research skills. Additionally, the majority of the students believed that the methodology optimizes the use of time allowing the execution of the experiments during the first two hours of the lab session (figure 3). The
implementation of the CPL allowed identifying theoretical concepts not properly understood by the students; the teacher explained such concepts during the lab sessions. The professors noticed a real students change of attitude regarding the experimentation of theoretical concepts and more interested in its performing.

The use of open questions (JITT) shown improvements related to deeper thinking in the students. However, some difficulties related to the preparation of lab reports and results interpretation were detected (figure 4). These problems were considered for the next phase of the project. Finally, related to the Moodle platform, problems were found related to students or teachers using it for the first time and repeated server failures. To solve the issues associated with the use of Moodle a training program was created by CEDEUIS. Regarding the server failures, the university will implement improvements to the ICT infrastructure.

4. Conclusions
With the implementation of the methodology described in this paper, we observe an improvement in research training in the Physics I laboratories of the ”Universidad Industrial de Santander”. In particular, the development and implementation of the CPL allowed identifying theoretical concepts not properly understood by the students while preparing a lab session. In general, the methodology strengthened the teaching/learning process. However, issues related to data interpretation and results synthesis were found. These problems have been taking into consideration for the implementation of the methodology in the Physics Lab for the follow academical semester.

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References
[1] Trujillo F 2011 “Enfoque de competencias en la educación: del conocimiento al uso y apropiación. Gestión de conocimiento” (Ministerio de Educación Nacional, República de Colombia)
[2] Balanskat A, Blamire R and Kefalaq S 2006 The ICT Impact Report: A review of studies of ICT impact on schools in Europe Tech. rep. European Schoolnet URL http://insight.eun.org/shared/data/pdf/impact_study.pdf
[3] Draper A J 2004 *Journal of Chemical Education* **81** 221
[4] Kesner L and Eyring E M 1999 *Journal of Chemical Education* **76** 920
[5] Prince M and Felder R 2007 *National Science Teachers Association (NSTA)* URL
  http://trove.nla.gov.au/work/16888534
[6] Novak G 1999 *Just-in-time Teaching: Blending Active Learning with Web Technology* Ellis Horwood Series in Environmental Management, Science an (Prentice Hall) ISBN 9780130850348
[7] Marrs K A and Novak G 2004 *Cell Biol Educ* **3** 49–61
[8] Birk J P and Foster J 1993 *Journal of Chemical Education* **70** 180
[9] Hake R R 1998 *American Journal of Physics* **66** 64–74
[10] UIS 2013 “Autoevaluación institucional 2013” (Universidad Industrial de Santander) URL
  https://www.uis.edu.co
[11] Cota A 2011 “Las competencias requeridas en investigación y su grado de estímulo en Ingeniería mecánica del instituto tecnológico superior de Cajeme” (ITESCA) URL
  http://www.itesca.edu.mx/investigacion/foro/carp ponencias/25.pdf
[12] Miranda D A, Martínez J H, Sanchez-Soledad M J and Gómez-Bayona L 2016 “Enfoque innovador de los laboratorios de física 1: formación para la investigación apoyada en TIC y estrategias de enseñanza/aprendizaje” (Universidad Industrial de Santander) URL
  http://posgradoseeie.uis.edu.co/boletines/trabajoscogestec2016.pdf