Student perception of the implementation of a teaching strategy based on Just in Time mediated learning and the use of information and communications technologies in the physics I laboratory course

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Abstract. A Teaching strategy based on Just in Time Teaching, mediated learning techniques and the use of information and communication technologies was implemented in physics I laboratory courses to improve research skills of second-level engineering students. In this work, a study into student’s perception of application of this strategy was carried out through statistical analysis of the responses given by students in perception surveys applied at the end of each semester. The study consisted of two parts: a quantitative analysis of closed test answers (questions with predefined answers) and a qualitative analysis of open answers (answers written by students). Programming codes in Python language were developed to perform the descriptive analysis of student responses from the first academic semester of 2016 (2016/I) to the first academic semester of 2018 (2018/I). Student percentage who answered "yes, they are enough" to the question if tools available in the Moodle virtual learning platform are useful for verification of the physical concepts, presented a tendency to rise (65% to 80%) along academic semesters. Also, qualitative analysis of the responses showed the need to train students in use of new technological tools (data collection software and devices) implemented in the laboratory projects in the last semesters. The above was concluded from the increased percentage of students who expressed difficulties in handling laboratory tools and devices (3.0% in 2016/I to 29% in 2018/I).

1. Introduction
In recent years, economic and environmental challenges worldwide have demanded the restructuring of higher education politics. Modern societal dynamics require abandonment of traditional teaching methods, in which students passively participate in their learning process, and implementation of teaching methods where students are actively learning [1]. Active learning comprises a set of teaching techniques that involve students in the classroom [2]. Recently, active learning implementation in courses of undergraduate programs in science and engineering has involved the integration of information and communication technologies (ICT). ICTs as Virtual learning platforms not only allow teachers to publish class activities but also provide quantifiable data about the technique effectiveness and student’s perception of it. [3,4]. Just in Time Teaching (JiTT) of active learning is a teaching strategy that allows assessment of the student's understanding of a topic before the classroom session [5]. With JiTT students answer questions proposed by the teacher according to readings and work material previously published in the virtual learning platform (Warm-Up). Then, the teacher evaluates the understanding of the key concepts detecting learning gaps and previous knowledge. This provides teachers with the opportunity to adapt class session in mediated learning activities that allow the
understanding of concepts [6]. Mediated learning activities involve student-teacher interaction to enrich the student's learning experience [7,8].

ExperTIC is an innovation project developed at the Universidad Industrial de Santander within the framework of the student permanence politics of the National Ministry of Education (MEN) [9] and the Academic Excellence System (SEA) of the university [10]. This project seeks the improvement of teaching-learning experiences in the courses of the Faculty of Sciences through implementation of mediated learning and active learning (JiTT) techniques supported by Information and Communication Technologies (ICTs) [11]. ExperTIC project implementation in the Physics I laboratory courses began in the second semester of 2015. At the end of each semester, a student perception survey was applied. Perception surveys consisted of questions about aspects of implementation, like the tools available in the Moodle learning platform, teacher accompaniment of practical sessions, strategy methodology and the ExperTIC experience in general. In this work, a study into student perception of the ExperTIC strategy was carried out through statistical analysis of the responses given by physics I laboratory students in perception surveys. The results of this study became useful tools for project researchers in the decision-making process to improve the project methodology.

2. Methodology

2.1. Strategy implementation

Physics I course for engineering students has a theoretical component and a practical component. Programs and independent professors handle each component. Physics I laboratory is the practical component of this course and corresponds to 20% of its final grade. Physics I laboratory is graded as shown in Table 1. ExperTIC methodology in physics I laboratory consists of three stages: before, during and after experimental session.

![Table 1. Physics laboratories grading.](table1.png)

2.2. Before experimental session

To prepare the experimental session, students reviewed the material available in the Moodle virtual learning platform, which includes research projects (laboratory guides), videos on the experimental methodology to be carried out, and data sheet models. JiTT strategy is applied to evaluate the student's understanding of the research project and to detect misconceptions before the experimental session. A set of laboratory preparation questionnaires (CPL) is proposed to students. CPLs consist of closed questions (predefined response) and open questions (student-written response) about the research project objectives, experimental methodology, data collection and data analysis. Bank of questions is reviewed and fed in each academic semester by the course teachers. Students responded the CPLs on the Moodle platform (tic.uis.edu.co) 36 hours before experimental session according to JiTT strategy. The web platform automatically closed and graded closed-questions while teachers reviewed open questions. Moodle platform configuration allows students not only to see their CPL grades but also to observe the comments and corrections performed by the teacher to each answer. The above is considered the first student-teacher feedback. In addition, students can perform a second student-student feedback in spaces outside of the experimental session.

2.2.1. During experimental session. Considering the CPL responses and misconceptions detected, the teacher began the experimental session with a third student-teacher feedback on the physical and methodological concepts not properly understood by students. Then, groups of three students carried out the experiments based on the previous revision of the published material.
2.2.2. *After experimental session.* After the experimental session, students are to elaborate the research report in accordance with the parameters published on the Moodle platform. A member of each group uploads the research report to the platform to be reviewed by the teacher. Before the next experimental session, the teacher publishes the report grade with its respective feedback for each group. Feedback allows students to perform the corrections suggested in the following report. As the last learning activity of the course, students propose and develop a final project based on a bibliographic review and the scientific method. Parameters of this activity are published on the Moodle platform. Each laboratory group performs a general presentation of the developed project and a written report.

2.3. *Data analysis*

Study of the student’s perception of ExperTIC strategy implementation in the physics I laboratory courses was carried out through statistical analysis of students’ responses in the perception surveys applied at the end of each academic semester. Programming codes in Python language were developed using Panda’s library to perform the descriptive analysis of student responses collected from the first semester of 2016 to the first semester of 2018. The study consisted of two parts: a quantitative analysis of closed questions (questions with predefined responses) and a qualitative analysis of open questions (student-written answers). Number of both students who participated in the study, and students enrolled in the course are presented in Table 2 for each academic semester.

| Table 2. Student population. |
|-----------------------------|
|                            | 2015-II | 2016-I | 2016-II | 2017-I | 2017-II | 2018-I |
| Participating student       | 595     | 352    | 183     | 208    | 363     | 103    |
| Enrolled student            | 647     | 400    | 546     | 501    | 523     | 516    |

2.3.1. *Quantitative analysis.* A quantitative analysis was carried out for three closed-questions. Question statements and their response options are showed in Table 3. Programming code developed allowed determination of students’ percentage for each response option.

| Table 3. Closed-questions and their response options. |
|------------------------------------------------------|
| Question statements                                   | Response options                      |
| 1. Did the tools available in the Moodle learning platform (project videos and research projects) facilitate the experimental verification of theoretical concepts? | 1. Yes, they did. 2. No, they did not. |
| 2. How often did your teacher feedback the evaluations of the research reports? | 1. Every fifteen days. 2. Every thirteen days. 3. Twice per semester. 4. At the end of the semester. 5. Never |
| 3. Did your teacher guide you appropriately during the experimental sessions? | 1. Yes, he did. 2. No, he did not. 3. His guide was unsatisfactory. |

2.3.2. *Qualitative analysis.* Qualitative analysis of open questions was performed through categorization process. For this study, two open questions were analyzed (Table 4). The responses were read carefully and organized into different categories. Each category was assigned an identification code (positive number). Response percentage for each category was determined by Python Code.

| Table 4. Open questions. |
|--------------------------|
| 1. What difficulties did you find in the course dynamics? |
| 2. What elements would you add to the Moodle platform to improve the learning experience in the course? |
3. Results and discussion

3.1. Quantitative analysis

Bar graph shown in Figure 1 indicates that student perception of the usefulness of the Moodle learning virtual platform tools in the experimental verification of physical concepts tended to increase through academic semesters. Student percentage who answered "Yes, they did" presented an increase of about 15% from 2015-II to 2018-I (65% in 2015-II and 80% in 2018-I). The latter can be associated with the continuous improvement undergone by the tools of the Moodle platform, such as better-quality videos on experimental methodology, easy access to tools, improved research projects, grades history and research report guide.

![Figure 1. Bar graph for closed question 1.](image)

On the frequency with which teachers performed feedback on research reports, the bar diagram did not show a tendency in student response behavior (Figure 2). In accordance with the ExperTIC project guidelines, research reports feedback should be carried out in each experimental session (every fifteen days) so that students will apply the corrections in the next report. The response option “Every fifteen days” had the highest response percentage in each semester but a variable behavior concerning academic semesters shows low assimilation of this practice by course teachers. Therefore, it is necessary to implement improvement actions with respect to this practice, since without appropriate feedback, it is not possible to correct errors in the research reports writing, data analysis and experimental results presentation. Since the research report is uploaded to the Moodle platform, a tool will be enabled with which the teachers can share the report feedback and corrections with each student. In the teacher training activities, teachers will be motivated to evaluate the research reports every fifteen days and make a general feedback at the beginning of the experimental session. ExperTIC project researchers every week will review the Moodle platform to follow up on the research report evaluation and give recognition to the responsible teachers with this activity.

![Figure 2. Bar graph for closed question 2.](image)
Figure 3 shows the bar graph obtained from the student's responses on teacher guidance during practical sessions. The percentage of student who thought that the teacher guide was adequate showed a tendency to increase from 2015-II (60%) to 2016-II (74%). Then, it reached a stable behavior at a value of about 80%. It is worth noting that the response option "Yes, he did" presented the highest percentage value in all academic semesters in which the study was performed. The above can be associated with the active participation of the course teachers in the teacher training activities organized by the ExperTIC project researchers. In these activities, the teachers receive training on the ExperTIC teaching methodology and they can propose improvement actions based on their experience.

![Bar graph showing teacher guidance during practical sessions](image)

**Figure 3.** Bar graph for closed question 3.

### 3.2. Qualitative analysis

In this analysis, the responses to open questions were classified into categories through the careful reading of each of them. These categories correspond to different elements of the ExperTIC methodology implementation in the physics laboratory courses. For the first question, 24 categories were defined, while for the second question 20 categories (Table 4) were. Each category was assigned an identification digit. Table 5 shows the eight categories with the highest response percentage for two questions. Frequency diagrams obtained for each open-question are presented below.

#### Table 5. Response Categories obtained in the open-questions analysis.

| Code | Question 1. What difficulties did you find in the course dynamics? | Code | Question 2. What elements would you add to the Moodle platform to improve the learning experience in the course? |
|------|---------------------------------------------------------------|------|-----------------------------------------------------------------------|
| 1    | Completion of the research report                            | 1    | Quality of research project videos                                    |
| 2    | Data analysis and treatment                                   | 2    | Applications to simulate experiments                                   |
| 3    | Neither                                                       | 3    | Neither                                                               |
| 4    | Experimental Set-up                                          | 4    | Improvement of research projects                                      |
| 5    | Lack of theoretical concepts                                  | 5    | Information on the use of laboratory equipment and instruments        |
| 6    | Bad-quality videos                                           | 6    | A student chat                                                        |
| 7    | Use of laboratory equipment and instruments                   | 7    | Material of physical concepts                                         |
| 8    | Data collection process                                       | 8    | CPL questions about research projects                                  |

Four categories related to difficulties found in the course dynamics showed a tendency to increase in the response percentage along academic semesters. These categories were: data analysis and treatment (11.0% in 2016-I to 16.8% in 2018-I), experimental set-up (6.0% in 2016-I to 12.0% in 2018-I), use of laboratory equipment and instruments (1.3% in 2016-I to 10.5% in 2018-I) and data collection (3.0% in
According to the student's responses, response percentage behavior in these categories was associated with the implementation of research projects that involve the use of new equipment and software in the last semesters (2017-I to 2018-I). The aspects mentioned by the students can be summarized as follows: the data collection process using tablets is confusing and complicated, since tables must be restarted repeatedly during the experiment, causing time loss; software handling used in the data collection is unknown to the teacher, and air rail calibration is complicated. These aspects suggest that although the students of this era were born surrounded by technology, they do not know how to use it, so in courses they must receive training on the use of the technological devices implemented [12].

It is worth noting that the category with name "Neither" (1.3), which corresponds to the student's percentage who mentioned not experiencing difficulties in the course dynamics (Figure 4), also showed a tendency to increase along academic semesters (6.5% in 2016-I to 17.9 in 2018-I). On the other hand, three categories presented a tendency to decrease in the response percentage: completion of research report (25.3% in 2016-I to 5.7% in 2018-I), lack of theoretical concepts (3.1% in 2016-I to 0.5% in 2018-I), and bad-quality videos (2.8% in 2016-I to 0.2% in 2018-I). The evident decrease in the student's percentage who mentioned having difficulties with the research report completion was due to the creation of a general guide. This guide contains a detailed description of each of the research report parts and it is published in the Moodle virtual learning platform for all students (Figure 4). On the lack of physical concepts, students expressed that the theoretical section in the research projects is complete and facilitates experimental verification and data analysis.

![Figure 4. Frequency diagram for the first open-question.](image)

Figure 5 shows the response frequency diagram obtained for the second open question, which referred to elements that would be included in the Moodle platform to improve the learning experience. Category with name "Neither" (2.3) that corresponds to the percentage of students who thought that the Moodle platform is efficient, and needs no more tools, presented the highest response percentage values in each academic semester. This category also showed a tendency to increase concerning the academic semesters, with 9% increase from 2016-II to 2018-I. The latter reflects the positive student perception of the continuous improvement of tools available in the Moodle platform. In addition, four more categories presented a tendency to increase the response percentage in the same academic period (2016-II to 2018-I): applications to simulate experiments (6.7% to 12.5%), information on the use of laboratory equipment and instruments (5.1% to 21.2%), student chat to solve doubts and questions (1.6% to 8.3%) and material of physical concepts (3.8% to 8.3%).

The noticeable response percentage increase for category five (2.5) can be associated with the difficulties found in the data collection process using tablets. Students thought that reviewing material (manuals or videos) on the use of these devices would save time in experimental sessions. Also, for this question three categories tended to decrease in the response percentage along academic semesters.
Category one (2.1) on improving video quality presented a decrease in 11.3%, resulting from the investment made in video recording of better-quality image, audio and information. Course teachers were trained to participate in the recording of these videos. The improvement of the research projects was observed in the reduction of the response percentage for category four (2.4). Students express that current research projects present a better composition and clearer explanation of the methodology.

Figure 5. Frequency diagram for the second open question.

4. Conclusion
The perception study described in this paper allowed us not only to detect those ExperTIC methodology elements susceptible of improvement, but also to measure the effect on student perception of actions previously implemented, as Moodle platform tools improvement and teacher training activities conducted each semester. The next stage in this investigation is the elaboration of the general improvement plan, considering the results of this study. Among the main actions proposed are training sessions for students and teachers on the use of tablets and software used in data collection, and production of videos on laboratory equipment operation.

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