The R&D Activity as a Supporting tool for the Active Teaching and Learning Methodology in an Engineering Course.

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Keywords—active teaching and learning, research, integration, binomial teaching-research, railway engineering, higher education, based learning problem, integration, Collaborative, Cooperative

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I. INTRODUCTION

Active teaching and learning methodologies have been discussed extensively by many previous authors [1-22]. In this sense, authors like: Prince [1] considers that teaching, in an engineering context, cannot be reduced to formulaic methods, and active learning is not the cure for all educational problems. Michael [2] concluded that, thanks to evidence about active learning, student-centred approaches to teaching physiology had better results than more passive approaches. Chickering *et al.*, [3] stated that applying good practices in student centred educational activities in undergraduate education:

1. Encourages contacts between students and faculty.
2. Develops reciprocity and cooperation among students.
3. Uses active learning techniques.
4. Gives prompt feedback.
5. Emphasizes time on task.
6. Communicates high expectations.
7. Respects diverse talents and ways of learning.

Duit *et al.*, [4] present a framework for improving science teaching and learning. Ruben [5] Yoder *et al.*, [6] found across theirs empirical results that the efficacy of active learning techniques is better in comparison with other formats, in line with Michael [2]. Michel *et al.*, [7] compared the impact of an active teaching approach and a traditional (or passive) teaching style on student cognitive outcomes in an introductory business course. According Felder [8] the idea of the teaching style is not to use all the techniques in every class but rather to pick several that look feasible and try them; keep the ones that work; drop the others; and try a few more in the next course. Felder considers that in this way a teaching style is both effective for students and comfortable for the professor will evolve naturally and relatively painlessly, with a potentially dramatic for his/her undergraduate students. Lantis *et al.*, [9] presents a state of the Active Teaching and Learning Literature.

Clayton [10] examines empirical studies on the use of concept maps as a teaching-learning method in nursing education. Bonwell *et al*., [11] proposed that strategies promoting active learning be de-fined as instructional activities involving students in doing things and thinking about what they are doing [12][13]. Ditcher [14] considers that aspect of the traditional model of engineering education, such as the widespread use of lectures, the overcrowded content and the assessment methods used, do not lead to high quality learning and PBL is one approach to overcoming the deficiencies.

Litzingeret *et al.*, [15] concluded that the current understanding of expertise, and the learning processes that develop it, indicates that engineering education should encompass a set of learning experiences that allow students to construct deep conceptual knowledge, to develop the ability to apply key technical and professional skills fluently, and to engage in a number of authentic engineering projects.

Dym *et al*., [16] present a work about the Engineering Design Thinking, Teaching, and Learning, where these authors consider that the currently most-favoured pedagogical model for teaching design, project-based learning (PBL), was explored in two contexts for PBL was emphasized: first-year cornerstone courses and globally dispersed PBL courses and

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Dym et al[16] concluded the most important recommendation is that engineers in academe, both faculty members and administrators, make enhanced design pedagogy their highest priority in future resource allocation decisions. Streveler *et al*.,[17] present a work about learning conceptual knowledge in engineering science. These authors [17] mentioned some of the most common conceptual difficulties from three domains: mechanics, thermal science and direct current electricity. Johri *et al.,* [18] explore the relationship between the learning sciences and the engineering education research and suggest ways in which the learning sciences and engineering education research communities might work to their mutual benefit. Larkin-Hein *et al.*, [19] demonstrated the value and importance of adopting a learning style approach in the classroom. This authors [19] provided evidence of the value of a learning style approach with two distinctly different populations of students. They consider that the attention given both populations of students in terms of individual learner diversity and learning styles is critical to the success of these teaching and learning strategies. The results presents in Freemann *et al.,* [20] indicate that average examination scores improved by about 6% in active learning sections, and that student in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. McCarthy *et al.,* [21] present a case about active Learning techniques versus traditional teaching styles. These authors [21] present two experiments with a undergraduate students from History and political science in a context of higher education. In this work, they showed that the students who participated in the role-plays and collaborative exercises did better on subsequent standard evaluations than their traditionally instructed peers. For Duffany [22] the main idea is that traditional classroom learning is very passive with the professor lecturing and the students listening. Active learning tries to engage students with a variety of techniques which are mainly variations of traditional teaching techniques. Duffany applied the active learning to an introductory programming course and gives several specific examples of how this might be done. Finally, Duran, et al. [23] concluded that incorporating good educational practices in the planning, design and implementation of curricular activities, including the use of virtual tools, generate a more changing environment in the teaching dynamics in the class room. Chickering *good practices* [3] reinforce learning activities since they include actions that faculty might hinder when planning and undertake educational activities.

II. REGIONAL LINK BETWEEN THE RESEARCH AND TEACHING IN THE UNIVERSITY

A. Brief of the Iberoamerican Context.

In the iberoamerican context, the situation about the state of the research activity is described in [24-42]. The document presents a brief summary about the research activities performed by a group of iberoamerican countries. In general, the research activity is concentrated at the official Universities [24].

Traditionally it has been understood that the university is an institution that simultaneously performs united activities of teaching and research indissolubly, and the university transfers the knowledge. This is established even by the organic or basic laws of education in several countries of the Ibero-American region. On the contrary, in practice, only a limited number of institutions combine this triad of functions in a broad and organic way, being able to aspire to the name of *research universities* by the number of scientific publications registered internationally during a certain period of years (See figure 1).

According to the report titled: "*Educación Superior en Iberoamérica Informe 2016. Primera edición"* [24], in iberoamerican there is a first group of 86 universities that deserve the qualification of *research university*, which is to have published more than 3,000 scientific articles during the last five years. There is a second group (92 universities), which are called *universities with research*, which during the same period produced an average of 200 to 600 scientific works per year. Then there is a third group - something more numerous - composed of 178 universities, called *emerging universities*, which register during the period of analysis between 250 and 999 scientific documents, that is, from 50 to 200 per year. In addition, there is a majority group of Ibero-American institutions - those that publish at least 1 article and up to 50 during the last five years - that can be classified as *incipient or sporadic research*. To these we can add the remaining about 2,600 universities in the region that are uniquely and *strictly teaching*, having not registered internationally any scientific article during the period under consideration. Brazil and Spain dominate the map of scientific production in the Ibero-American region. While Brazil has the largest number of universities defined as «*Research University*» and *«University with Research*», Spain leads in «Research« Universities. They are followed, with more than ten universities per country, Mexico, Argentina, Portugal and Chile.

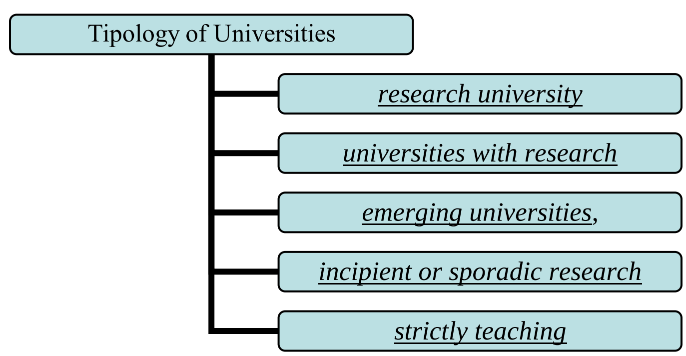

Fig. 1. Typology of University according [24]

III. ACTIVE LEARNING AND TEACHING. CASE STUDY: TÓPICOS DE ACTUALIZACIÓN TECNOLÓGICA (TAT).

This study was conducted during a one semester class in the fourth year of the Electromechanical Engineering program, at the College of Electrical Engineering in the Universidad Tecnologica de Panama (UTP). The class is a free curriculum class named *Tópicos de actualización tecnológica* (New Topics in Technology). The aspects of curricular subjects for the particular semester under study were related to railway engineering and rail transportation by metros, railways and tramways.

Berbey [43] presents a proposal model to analyses the effect of dissemination of the research´s results on teaching activity at Technological University. It was done with a case study technique. The experience gained in research´s activities across of the creative work of generating own publications is vital, when it is necessary to insert new content in an agile, efficient and sustained way inside of the any current engineering career curricular structure.

For Sanchez [44] the research activity increases absorption´s capacity of new knowledge. Any university, with human resource working in R & D activities, is observing systematically the technologies that are coming out. When the academic staff has the transcendental habit of technological surveillance, then the absorption´s capacity within and out of the university, is much better, even if it is not the university who will use these new technologies directly. Due to it, the effect of spillover to higher education occurs, with the power of change the society. The research activity at the university does not only generate new knowledge, but also brings the knowledge of what is happening outside, serves as a prospecting technology activity for society, and in addition, the research activity changes the student's relationship with the knowledge. In other words, the knowledge is not only something acquired exclusively from a book from written in a highly developed country. The knowledge is a concept that is created thanks to the active participation of the faculty-researchers entity. Faculties are a protagonist with their own personality, even if this new knowledge is not significant y amount. This new knowledge changes the attitude of the students and the attitude of the faculty, due to their own creative active voice. It empowers them.

In the study case presented by Berbey [43], the effect of active

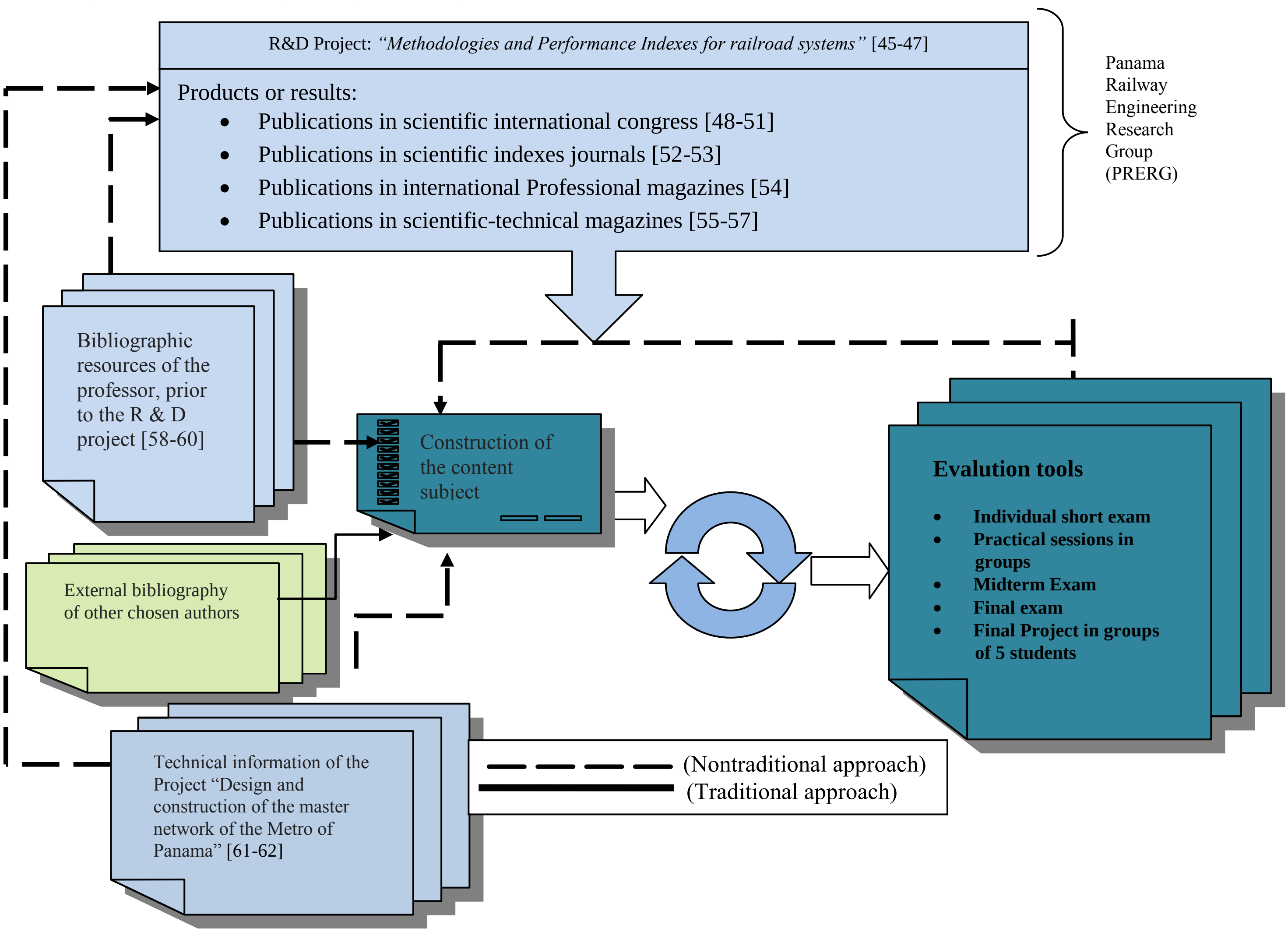

Fig. 2. General Scheme of the dissemination effect of the research activity in the teaching learning process [43].

dissemination of the results of research [45-57] occurs as a consequence of convergence of complementarity between teaching and research activities studied by authors like: Perdomo [63], Mitchell *et al.,* [64] Tesouro *et al.,* [65] and Molina [66]. In other words, the results of the research activity [45-57] are transformed in new contents in the teaching activity. These are the new didactic resources. The innovation of these new curricular contents is guaranteed by the validation process of external reviewers, via previous publications in congress or scientific journals.

In the scheme [43] outlined in Figure 2, the discontinuous line corresponds to the faculty-researcher's methodology while the continuous line corresponds to the methodology of the traditional professor, who doesn't perform any research´s activity at the university. This scheme only corresponds to local and some regional models of teaching-learning activities at the universities.

In this context, the traditional professor extracts the theoretical content of any course from a set of listed university textbooks and adapts it to the teaching act in the classroom without providing the knowledge generated via the process of his/her own scientific publications. This approach is very reactive and diminishes the role of the professor in the classroom, making him or her a passive and diminished voice, although dominating the classroom since the professor is the only person who knows the topics covered in the lectures. The professor- researcher is the one who transfers the new knowledge because of the results of the researches conducted and their scientific publications to the teaching act, either through oral presentations, reading assignment and subsequent evaluation of his/her own scientific articles to the students. Additionally the professor-researcher stimulates designs and evaluates the final projects of the subject by group of undergraduate engineering students.

The professor-researcher is a professor with an active voice, because his/her own scientific production is part of the universal thread of the construction of new knowledge, even if it is an infinitesimal part of the vast knowledge in a particular topic. It is possible because his/her research work has been evaluated by a group of experts during the process of evaluation by external peers. Because of this process, the professor-researcher cannot influence in the final evaluation valuation of his/her research.

In addition, the professor- researcher is in permanent contact with other scientists who are working in similar or even collateral areas, while the traditional professor does not conduct any research activity, thus he/she is not member of the selected network or experts in his/her research area. Salas et al., [67], for example, consider that research groups are the basic unit for the generation of knowledge. The individual contribution is merged and increased; the final knowledge becomes a synergic product. Therefore it is more than the sum of the parts.

The curricular content of the courses taught by a traditional professor is always influenced by writings of other authors, without a contribution of his/her own voice. For the traditional professor, the inclusion of new contents, analysis of data, specifications of engineering works with new technologies within or outside the country, as in the case of the Panama Metro network, could result more complex because the traditional professor has a reduced activity of search, consultation, inquiry of new technologies, contents, etc., as compared with the professor-researcher, who for his/her research activity is exposed constantly to the arguments, findings, references, models development, simulations, analysis, and experiments, which allow the professor-researcher a better understanding of an existing or new technology. The relationship between the binomial teaching-research [63] serves to enrich the two activities, cornerstones of the current university [68].

In this sense, the existence or not of links betweeen research and teaching produces, according Henkel [69] strong differences between the identity of many academics.

Barbon *et al*.,[68] uses a three-stage methodology for the development of his experience of integrating the results of research in teaching. The three-stage are:

1. Selection of results. Experiences like Berbey [43][70] show that not all activities, results or research products of a research project became active or didactic resources for teaching. For Healy [71], most of the academic staff, when asked about how their research impact on teaching, indicate that the impact in the way that their research findings (results) are integrated in their lectures.

2. Relationship between results and subject matter. In this sense, according Jimenez et al., [72] teaching is one of many areas of any university to be benefited by research processes and results. The knowledge transfer in the classroom requires tactical and special methods that makes it possible to transform <u>a high-level language, usually associated with research [68]</u> into an understandable language that might be applicable by professors and students. According Badley [73], here it is interesting to mention that it is really useful (and more stimulating) approach is to regard research and teaching as two different) but overlapping processes of inquiry.

3. Results presentation. In this stage is important to present the research results in a way (representation) attractive and affordable for the better understanding.

IV. Experimental results

Figure 3 presents a general scheme about the experimental results of the 3-questionaries. Here, the general idea is proposed a methodology of integration of the results of research in teaching by evaluate the insertion of the research in the active teaching –learning process.

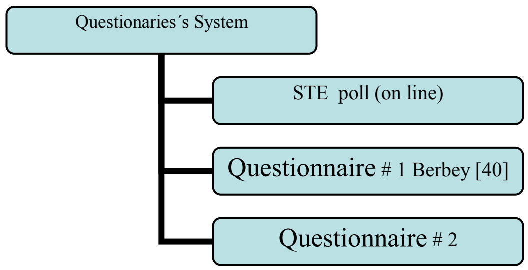

Fig 3. Squeme of questionaries

A. *Standard teaching evaluation (STE)*

The Standard teaching evaluation (STE) corresponds to an online survey at the end of any engineering course. This poll has a total of 20 questions. The grading scale corresponds to that established in the University Statute 23 of the Technological University of Panama [74]. Each student completes the online questionnaire for each one of the subjects prior to seeing their final grade to avoid bias in the responses emitted by the undergraduate engineering students. However, the current Faculties evaluation used widely in the Universidad Tecnológica de Panama, does not evaluate specifically the insertion of research content in teaching act, nor the carrying out of research activities with students in classrooms.

B. *First questionnaire*

Berbey [70] presented a questionnaire to evaluate the insertion of research in university teaching across a case study applied to an engineering course at the College of Electrical Engineering.

Berbey [70] presented preliminaries results by the application of a questionnaire to a total of 46 fourth-year electromechanical engineering undergraduate students. The main objective of the first questionnaire was to establish pilot measurements for the insertion of research results into university teaching. The survey was applied to groups of students who took or were taking the subject Tópicos de Actualización Tecnológica (New Topics in Technology) and other groups of students who have studied other subjects of the program such as Physics I (first year course) and Programmable Logic Control (Fourth year course) students respectively. The questionnaire has a total of 7 questions. In Berbey [43] it is possible to consult to fundamental basics that support this survey to measure the insertion of results of researches in the higher education activity. The surveys were applied anonymously to a group of 75, including the ones in Tópicos Avanzados, Physics I and Control. Of the total of those 75 students surveyed, 46 corresponded to students who had taken the subject of Topicos de Actualización Tecnológica during the years 2014, 2015 and current 2016 and the others 29 corresponded to students who took other courses during the year 2016 in the same College.

The questions were designers to investigate aspects about the insertion of research results in the teaching/learning process in the classroom. The first two questions are demographic and general aspects: such as semester, course year, and if the engineering student takes or not the TAT Subject.

3. Does the Faculty of this subject use research results as didactic resources?

4. What kind of research results does the teacher use as a didactic resource during the course?

5. What kind of evaluation instruments were used or are used to evaluate the research results used by the Faculty didactic resources during the course?

6. How much time does it take you to assimilate these didactic resources resulting from research projects before summative testing?

7. Do you consider that the use of didactic resources, used in this subject arouse your interest for a future scientific research career.

In Berbey [70] can be appreciate the complete results of the application of this questionnaire # 1. Doing a brief of this previous work, mention that:

With respect the question # 3, all the 46 students surveyed in the (TAT) subject identified and answered affirmatively about if Faculty of this subject use research results as didactic resources.

For the question # 4, the results showed that the percentage levels of recognition of the didactic resources coming from research results were significantly superior for the TAT students in comparison to the students of the other courses of the electromechanical engineering career.

For the question #5, in the case of other courses, it was evident that all the percentages of use of evaluation instruments coming from research results in each of the 7 categories are significantly lower in comparison to these same instruments in the TAT subject.

With respect to the question # 6, the results showed that the assimilation time of contents of research results in TAT subject by the students surveyed takes mostly from 30 minutes to one hour clock.

Finally, the results of the question # 7, showed that the didactic resources from the research results used in the TAT subject aroused a greater interest of 84.78% compared to 65.52% of the didactic resources of the other subjects.

C. *Second questionnaire*

The design of second questionnaire corresponds to other institutional poll. It was designed out of the Faculties by the vice academic principalship. This second questionnaire was named: *Encuesta sobre el Proceso Enseñanza-Aprendizaje* (Survey on the Teaching-Learning process). This second questionnaire was answered by 28 electrical engineering faculty members. These faculties were teaching a total of 44 engineering courses during the second semester 2016. For example, one faculty completed one or since 4 surveys during this period. Finally, the total number of polls completed by all the faculties was 53. This questionnaire has 4 questions and an additional section for additional comments. The results for this second questionnaire are as follows:

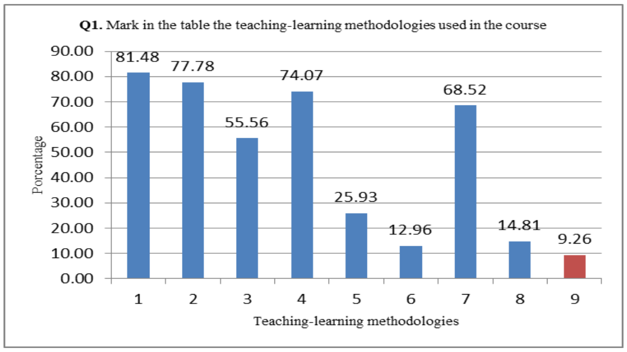

Fig 4. Teaching –learning methodologies used in engineering courses.

Table 1. Code used for the Question 1 in the questionnaire 2

Code	Teaching-learning methodologies
1	Lectures
2	practical classes
3	lectures
4	teamwork
5	workshops
6	tutorials
7	laboratories
8	technical visits
9	Others

In the figure 4, the results indicate that the main teaching-learning methodologies used are: lectures (81.48%), practical classes (77.78%), teamwork (74.07%), laboratories (68.52 %) by electricial engineering faculty professors. Only in the teaching-learning methodologie named others, these professors mentioned resources like: scientific articles in congresses, scientific articles in journals, data set, professional articles in magazine, scientific posters and targeted projects. In this sense, Berbey [39] designed, and applied a first questionnaire and showed result more specific about the insertion of didactic resources in teaching activity from published research results. In this sense, the results of the first questionnaire [39] are more direct, specific when we do the comparison between the question 4 of the first questionnaire and the question 1 of the second questionnaire, *(What kind of research results does the teacher use as a teaching resource during the course*?). In other words, the figure 5 about question 4 of the listed the research products or results like didactic resources used in an engineering course.

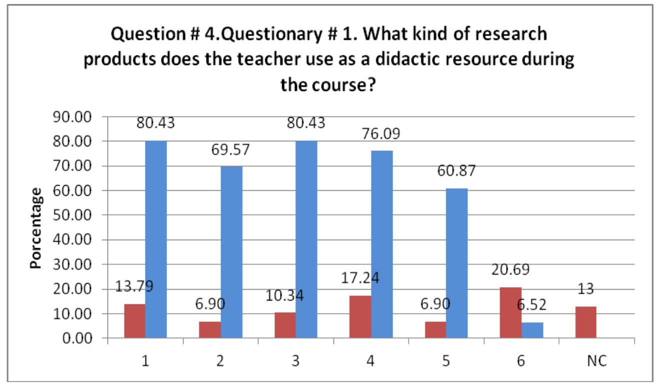

Fig 5. Results of the question # 4 of questionnaire # 1[39]

Table 2. Code used for the Question 4 in the questionnaire 1.

Code	**Products or research results (didactic resources**
1	Publications in scientific indexed journals
2	Publications in scientific international conferences
3	Publications in international Professional journals
4	Publications in scientific-technical journals
5	Scientific posters
6	Others, please specify:
NC	No answer

In the question 1 of questionnaire 2 (*Mark in the table the teaching-learning methodologies used in the course*), it can be seen that the practical classes had a high percentage of 77.78%, while in questionnaire 1, this same aspect reaches the value of 20.37%. Conversely, in questionnaire 1, designed with objective of measuring the insertion of research in teaching, the percentage to the final research project is considerably high 83.33%, while in the questionnaire 2 this aspect is hidden in the category of others with a 9.26%. This situation was notorious in Berbey [34] when is analyzed the standard institutional evaluation (STE) of the academic performance. This STE applied on line lack any questions about the insertion of research into the teaching-learning act.

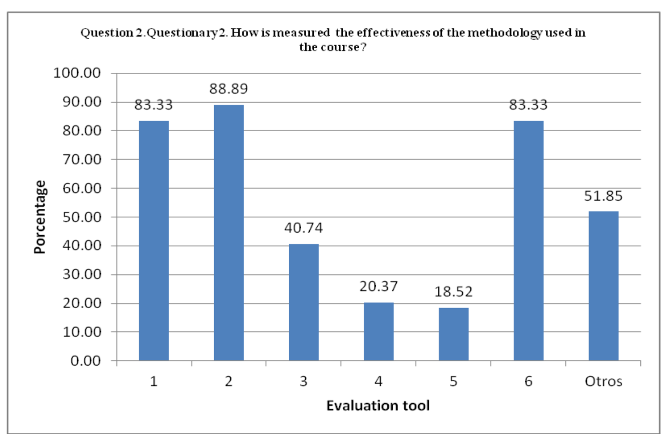

Fig 6. Evaluation tools used in the engineering courses.

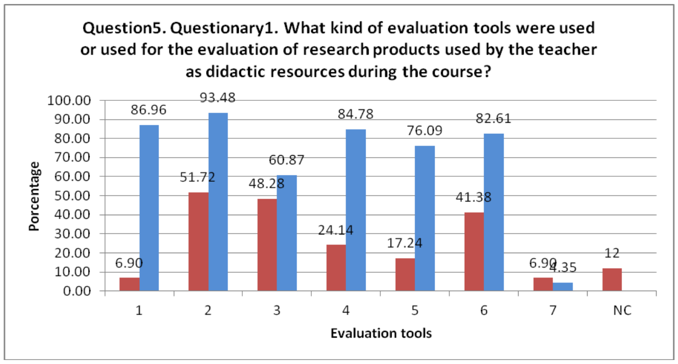

Fig 7. Results of the previous questionnaire #1 [39]

Table 3. Code to Methodology/Evaluation Tool

Code	Methodology/Evaluation tool	
	Questionnaire #2	Questionnaire #1
1	Probing questions	Quices
2	Partial exams	Parcial exam
3	Group oral presentation	Final exam
4	Quices	Group practices in the classroom
5	Individual oral presentation	homework
6	Final exam	Projects
7	Others	Others

The results of the question 2 of the questionary 2 that the main principal evaluation tool is the partial exams (88.89%), there is a dead heat between probing questions and final exam, both reaches an 83.33 % respectively. It is interesting see that the 51.85 % refers to others evaluation tools. The professors mentioned use like evaluation tool: final project, final article, scientific article, projects. Again, this questionnaire 2 has the same problem of the STE poll, both questionnaires hidden the institutional research activity (See figure 6).

Question 3 of the questionnaire 2 that say: *Indicate the educational strategies used in the course* showed that the principal educational strategy used is homework (72.22%) in the engineering courses of the electrical engineering faculty. Followed by a dead heat between researches and problems solving with a 70.37%, respectively. In the third place, the Brainstorming strategies showed a 61.11 %. The percentage of 59. 26% corresponds to project educational strategy. Con respect to the project educational stratgy, Guerrero *et al.*, [75] presented results that indicated significant improvements in the student´s skills, which can be attributed to the use of project-based learning educational strategy as one of the possible ways to improve generic competencies of the students. It is a powerful tool that balances and complements engineering curriculum. The professors mentioned like others educational strategies (5.56%): elaborate scientific articles, researchs and proyects.
It is necessary to mention that the samples chosen for both the first and second questionnaires were electrical engineering faculty because, according Berbey [70] and UTP [76], this college presents the university's first place in scientific production during the decade 2003-2013 (30.48 %), followed by the the College of Computer Systems Engineering (15.81 %) and The College of Mechanical Engineering (11.13 %). The scientific production corresponds to three fundamental categories as: conferences articles, articles in indexed journals and articles in no indexed journals and journal no indexes articles.
Regarding to question 3 of the questionnaire 2, it can be seen that the identification of the insertion of the results of the research activity into teaching practice remains a problem. This situation is especially evident when the questionnaire 2 is compared with the results and structure of the questionnaire´s questions 1. However, survey 2 shows an improvement over the standard institutional evaluation (STE) of the academic performance. As this is evidenced in the results of question 3, with respect to the aspects (4) and (5) respectively because it is possible to observe that of 70.37%, 59.26% of respondents answer for aspects such as: research and project, respectively (See figure 8).

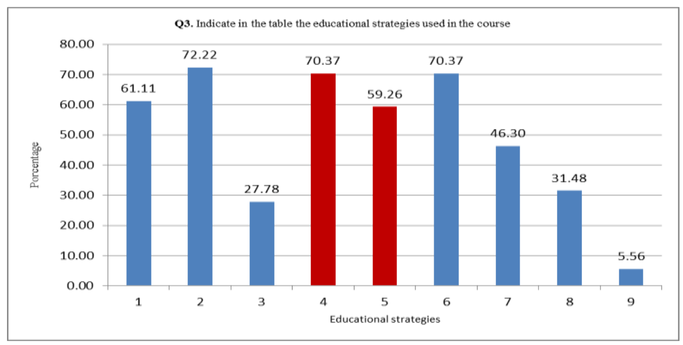

Fig 8. Educational strategies in the engineering courses of the electrical engineering faculty. Question # 3 of the questionnaire 2.

Table 4. Code to teaching-learning methodologies.

Code	Teaching-learning methodologies
1	Brainstorming
2	Homework
3	lectures
4	research
5	Projects
6	Problems solving
7	Use of ICTs
8	case studies
9	Others

For the questions 4 of the questionnaire 2 about ICTs used in class, the faculty answered the following order of used of ITC´s: Internet (92.59%), email (88.89%) and personal computer (68.52%) according the results presented in the figure 7. In the case of the results of question 4 of the questionnaire # 2, the results show that teachers use in their vast majority as ICT: Internet (92.59%), email (88.89%), personal computer (68.53%) and software 55.56%). ICTs resources with higher percentage values refers to those that are privately owned by professors rather than institutional resources such as virtual classrooms (5.56%), Moodle platform (11.11%), video conference (7.41%), even the mobile phone (25.93%) and the WhatsApp (33.33%) have a higher percentage compared to the latter institutional resource. In this sense, it is important to clear that although the internet is in the list of institutional resources, its quality is very poor by skype, video conference, etc. and this is used privately by professors from their homes. (See figure 9).

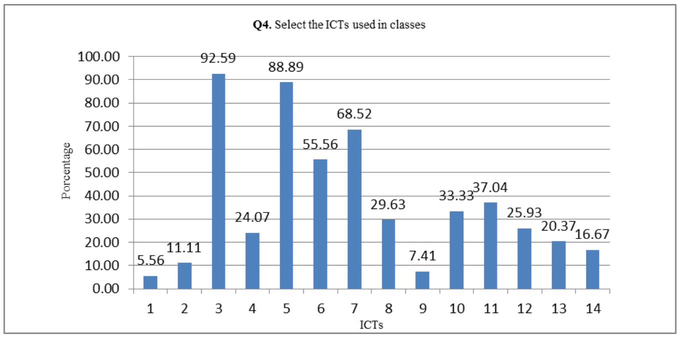

Fig 9. ITC's used in classes.

Table 5. Code about the ICT´s used

Code	ICT´s
1	Virtual classrooms
2	Moodle platform
3	Internet
4	Virtual library
5	Email
6	Software
7	Personal computer
8	YouTube
9	Video conference
10	WhatsApp
11	Audio and video player
12	Mobile phone
13	Dropbox
14	Other

V. CONCLUSIONS

The insertion of research findings is an active way of teaching and learning. This manuscript compares the results of two questionnaires applied to two different group of individuals. The first questionnaire is applied to Electromechanical Engineering undergraduate students. The second questionnaire is applied to professors. Both questionnaires were applied in the College of Electrical Engineering at the Universidad Tecnológica de Panamá. In resume, the STE applied on line lack any questions about the insertion of research into the teaching-learning act, while Berbey [39] designed, and applied a first questionnaire and showed result more specific about the insertion of didactic resources in teaching activity from published research results. In this sense, the results presented by Berbey [39] are more direct. Again, this questionnaire titled "*Encuesta sobre el Proceso Enseñanza-Aprendizaje* (Survey on the Teaching-Learning process)" has the same problem of the STE poll, both questionnaires hidden the institutional research activity. However, survey 2 shows a timid improvement over the standard institutional evaluation (STE) of the academic performance.

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