Impact of Formative Research on Engineering students

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Abstract- When the research is taught without any articulation between the academic world and the research, it does not have outstanding results, one of the big problems is the way to develop the research capacities in the engineering students. In the University of Sciences and Humanities, they implemented a formative research system to strengthen these capacities through three programs. The first program involves students from the 1st to the 3rd cycle where research habits are developed. Program II involves the 4th to the 7th cycle where scientific thinking is developed in the selected courses of the specialty. Finally, program III from 8 to 10 of the cycle in which contact is made and the visibility of the research through the final development of the research work and its publication in various congresses and academic events. The strengthening of the research capacities of the students was achieved from having 0 publications in 2016 to 11 publications at present, as well as the articulation of formative research with productive or formal research.

Keywords-Training research system, research programs, publication on paper by university students, scientific thinking, research habits.

I. INTRODUCTION

Research is a fundamental function of the university; it constitutes a very important element in the educational process because through it, knowledge is generated and learning is fostered for the generation of new knowledge; In addition, the research links the university with society [1]. As shown in fig. 1 scientific production by Ibero-American countries is minimal.

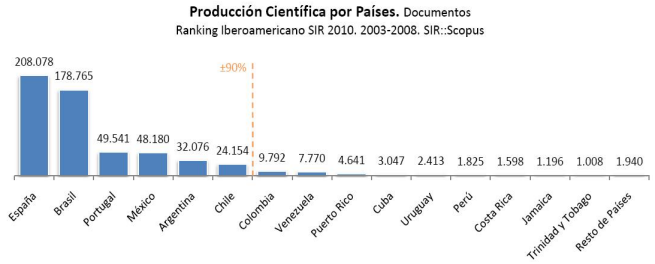

Fig.1 Scientific production by countries according to the published documents, Iberoamerican Ranking 2010.

For this reason, universities must develop capacities for research in students and incorporate research as a teaching-learning strategy into the curriculum [2]. Similarly, if we talk about the quality of higher education, it is intimately associated with the practice of research. [3]. In Latin America there are very few universities that carry out formative research in undergraduate students.

According to National Superintendence of University Higher Education (SUNEDU), 1.2 million Peruvian students' study at one of the 143 universities in Peru and only 32 are dedicated to research, all having common objectives: to try to solve a real problem.

When we talk about the term "Formative Research", it is "to train" in and for research through activities that are not necessarily part of a specific research project. Its intention is to familiarize itself with the investigation, with its nature as a search, with its different phases and functioning. The purpose of the formative research is educational; its methods are flexible and didactic and are adapted to the needs of teaching learning [3].

It has two additional fundamental characteristics: it is a research directed and oriented by a professor, as part of its teaching function and the investigating agents who are not research professionals, but subject in formation [4].

The formative investigation, in the field of the pedagogical function of the investigation, counts on methods and practices of investigative teaching rehearsed by the institutions and the university professors and that have demonstrated certain effectiveness. [5]. It is also a changing and dynamic process and shows how education in Colombia has evolved more directly, generating educational construction, from the competencies of students. [6]

According to statistical data provided by SCimago in 2014, of the universities that carry out research in Ibero-America, it is clear that Peru is not among the top 100.

The objective of this research work is to strengthen the research capabilities of students through the implementation of a training research system.

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The present work is structured in the following way, in section II it will be described in greater detail about the methodology used for the design of the system. In section III the results obtained will be evidenced and finally in section IV the own results will be discussed and the conclusions presented.

II. METODOLOGY

The implementation of the Training Research System was divided into two stages: In which the planning or design of the system was carried out, the guidelines were determined, the instruments, guides were constructed and then the implementation stage was passed.

A. *Stage I*

In this stage, the three research programs were designed and planned, for which the courses were selected taking into account the research lines of each Professional School, as well as identifying the articulatory courses between each program. Then a team of teachers of the specialty was formed who reviewed and improved the posters, syllables, in which the investigative capacities in the content of the same were specified, it was stipulated that the students should develop and present in a final project as a work of research, for which tools such as rubrics, research guides, regulations for writing and the use of investigative tools such as Mendeley, Turnitin, SPSS and others were developed.

One of the dimensions of the integral educational model of the University of Sciences and Humanities is research, which is developed at the pre-graduate level and is divided into three major programs:

1) *Program I:* Elementary
2) *Program II:* Intermediate
3) *Program III:* Advanced

Fig. 2 shows the three programs that form the formative research system and the courses that articulate and strengthen the research capacities, throughout the 5-year engineering career.

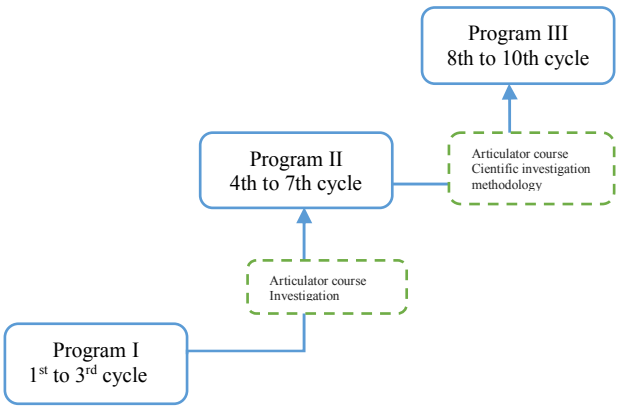

Fig. 2 Diagram with the three programs of the formative research system and the courses that strategically articulate each program for the achievement of the capacities.

Another important change was to rethink the form of evaluation of these courses progressively, taking into account the review of two progressive advances with added value, a review of the research work and an exhibition of the research topic, all in the Unit and in the same way in the II Unit of the academic cycle, having a constant and progressive evaluation of the work through processes and investigative tools that will allow an evaluation of the development of the investigative capacities.

1) *General guidelines of formative research:*

These guidelines were ruled to strengthen the abilities of students and have the following purposes:

a. Develop guidelines were ruled to strengthen the abilities of students and has the following purposes.
b. Achieve the development of the research work to obtain the bachelor's degree and the thesis for obtaining the professional title forming research engineers.
c. The formative research uses the scientific method to develop the investigate capacities of the students in their professional training process, for this it must have a qualified advisor with investigative experience.
d. This system has a guideline, which includes the research topic, the appropriate methodology according to the professional school, the data collection, the argumentation, the conclusions and a final product according to the program, all under the general guidelines as shown in the table I.

TABLE I. GENERAL GUIDELINES OF THE FORMATIVE RESEARCH SYSTEM

PROGRAMS	GUIDELINES
PROGRAM I 1st to 3rd cycle	1. For the collection of information, it is compulsory to use a specialized database according to the professional school, as well as bibliographic managers and other research tools.
PROGRAM II 4th to 7th cycle	2. All academic work must be presented with their respective citations and bibliographic references established in the guide of each program. 3. The subjects considered in the program I, II, III must be reviewed using the Turnitin, and must not exceed 25% similarity.
PROGRAM III 8th to 10th cycle	4. To continue with the subjects established by program III, the student must present proof of participation or assistance in (03) scientific events related to their career. 5. To have the authorship of the research work, you must register it from the 9th cycle, otherwise you will not have the author's right. **6.** For each program considered as part of the formative research, you must present an academic product (essay, monograph, project, article) as stipulated by the General Studies area and by specialty of each Professional School.

B. Stage II

In the II stage the implementation of the programs of the formative research system was set in motion as detailed below:

1) Program I: It includes the general training courses from 1st to 3rd cycle, under the responsibility of General Studies and the accompaniment of the Research Unit of the Faculty of Sciences and Engineering with the aim of achieving the following capabilities:

- To Read, write and
- To argue

a) Guideliness:

The subject of the first Cycle, Interpretation and Production of Texts is aligned and articulated to the Research, therefore, it is the basis for the development of investigative skills and lay the foundations for the subsequent development of the essays, monographic works, articles and theses of the students.

The subject of the second cycle, Writing and Argumentation is aligned to the research focusing mainly on the writing of academic essays.

The subject of the third cycle, Academic Research is the one that articulates the program II, is directed to the elaboration of a basic work of investigation (Monographs). It is proposed to develop general aspects of intellectual work and formative research.

The research is born of curiosity, of wondering about the why of things, of the desire for permanent search, feeds on reading and conversation about scientific novelties, the posing of problems, the handling of hypotheses, the intellectual work in team students- teachers, among other attitudes and research habits that is achieved in this first program.

2) Program II: It includes professional training courses from the 4th to the 7th cycle, under the responsibility of the Academic Research and Direction Unit of each Faculty, with the aim of achieving the following capabilities:

- Understands, analyzes and applies the knowledge acquired in the subject in the writing of an academic paper (projects level 1, 2, 3 and 4).

a) Guidelines:

The research topics of each course are framed according to the lines of research established by the corresponding Professional School, for the subsequent development of the projects.

Each selected course has approaches and levels. By approaches we understand the experimental rationalities, which covers descriptive, explanatory and experimental levels proper in each one of the specialty courses.

The subject of the 7th cycle, Methodology of Scientific Research (MIC) is the one that articulates the program III.

The subjects of this program articulate and integrate the curricular components of knowledge using research as a means of inquiry, search and learning to solve society's problems.

3) Program III: It includes the research courses of the 8th to 10th cycle, under the responsibility of the Research and Academic Management Unit of each Professional School, with the aim of achieving the following capacities:

- Identify and analyze social problems.
- Develops and analyzes the development of an academic article
- Prepares and designs a project.

a) Guidelines:

The teacher becomes the guide that helps to find the capacities, motivating them to investigate by investigating with them, the student is the interpreter in the construction of their knowledge. [7]

All these programs are monitored by the Research Unit of the Faculty, with selected and articulated courses, as well as team work among students, teachers, researchers and corresponding areas, as shown in fig. 3 and fig. 4.

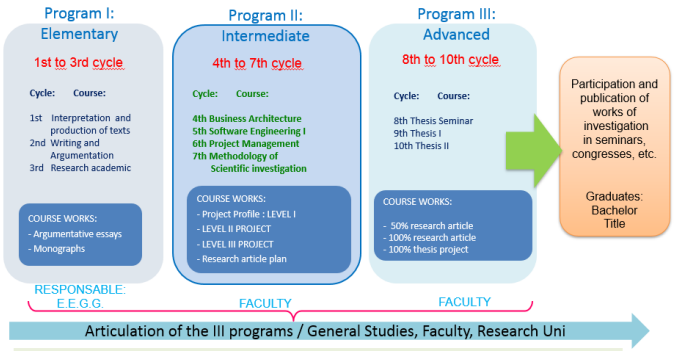

Fig. 3 Formative Research System - Systems Engineering.

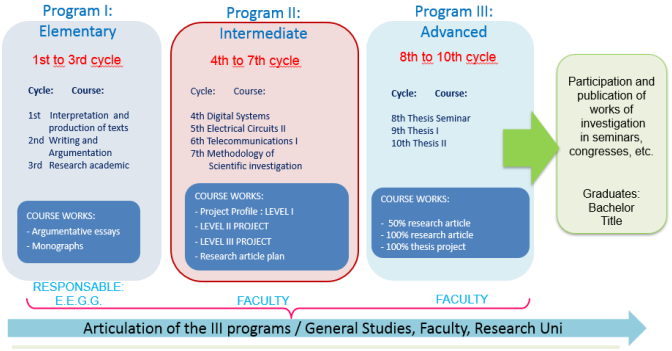

Fig.4 Formative Research System - Electronic Engineering

University research is conceived based on the curricular structure, such as: Academic process in which pedagogical resources develop student learning. A dynamic is generated around the knowledge that must exist in all academic processes. [8]

And in relation to the investigative process, results are shown in final products; as the research work of each of the selected courses and more demanding as the programs progress, so that new knowledge is generated [9] which is evidenced in publications in seminars, congresses and other academic events.

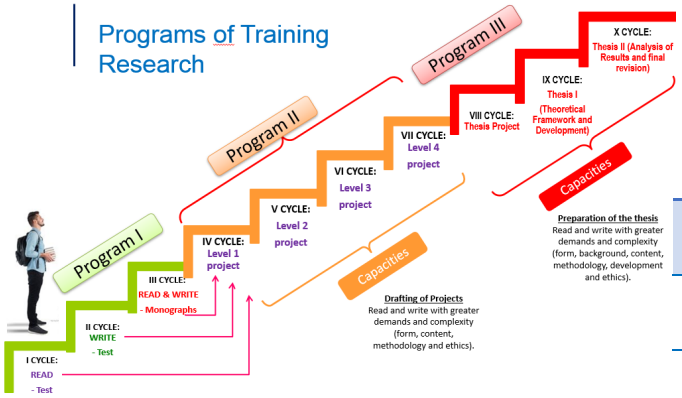

Fig.5 Formative Research System and achievement of capabilities

The training research system has been developed since 2016, through teamwork with teachers, researchers, academic and administrative departments, and the Directorate of Academic Research and Management [10], being consecutive programs as shown in fig. 5.

III. Results

After applying the formative research system, it was possible to gradually strengthen the students' abilities, as detailed in table II.

TABLE II. ACHIVED CAPACITIES ON STUDENTS ACCORDING THEIR PROGRAMS

	ACHIVED CAPACITIES
PROGRAM I	Critical analysis Argumentation Systematization
PROGRAM II	Presentation of proposals Tool optimization Problem solving
PROGRAM III	Argumentation of ideas Problem solving Synthesis capacity Teamwork. Rigorous research

A year after the training research system was implemented; the significant increase in the publications of the theses of the engineering students in the institutional repository was evidenced, as shown in the fig. 6.

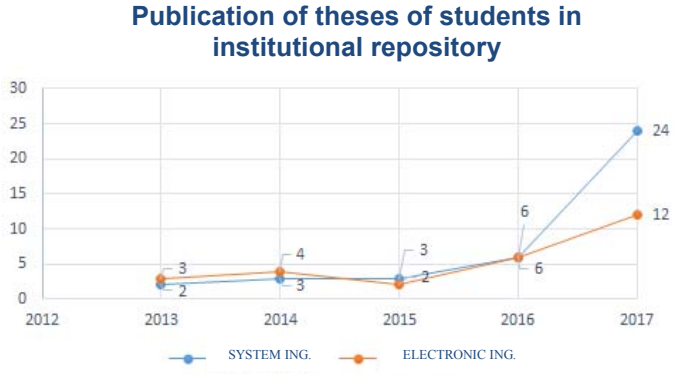

Fig.6 Publications of the research work of engineering students in the Institutional repository.

The level that they are reaching in each of the programs is evident in the research work that they present in the different congresses both nationally and internationally, as shown in the table III.

TABLE III. RESEARCH ARTICLES PUBLISHED ON THE CONGRESS

STUDENTS / CONGRESS	NAME OF INVESTIGATION
Brian Meneses Claudio ECI2018i	Design of a bioimpedance analysis system for children from one to eight years old
Gerson Delgado Rivera ECI2018i	Method for the segmentation of the palpebral conjunctiva
Eliseo Chávez Alarcón ECI2018i	Vehicle flow analysis using the automatic vehicle counting method.
Witman Alvarado INTERCON 2018	Design of a 3D Printer and Integrated Supply System.
Anderson Mujaico Mariano, Martha Medina De La Cruz INTERCON 2018	Implementation of a mechanical-electronic system for 7 to 11-year-old children with Duchenne muscular dystrophy.
Edgardo Lozano Cotrina INTERCON 2018	Detection of Minerals Through the Processing of Satellite Images.
Víctor Romero Alva NACIONES UNIDAS-RUSIA 2017	Urban Growth Planning of Chinchero (Cusco) Using Satellite Images.
Ruth Patricia Condori Obregón CONIITI 2018	Comparative Study of Methods to Improve Administrative Processes in an Organization
Oscar Trinidad Quinoñez CONIITI 2018	Knowledge of the benefits of blood donation as a method of awareness in the university community in Lima - Peru.
Janfranco Llave Herrera ICA/ ACCA 2018	Where are the prisoners in prisons in Lima, Peru? One answer using the gray grouping method
Betsabe Ayala Huamani INTERCON 2018	Application of Shannon's entropy to analyze the level of the health system by departments in Peru

The university is forming this way engineers and researchers who have an adequate level of research capabilities result of joint work of Formative Research, which conducted during their work when necessary.

IV. Discussion and Conclusions

Unlike other universities that have been doing research for years and have all the necessary logistics, resources, experience, personnel and specialized laboratories, an articulated and collective work of each of the areas is being carried out at the University of Sciences and Humanities. Corresponding to achieve the formative research in students and teachers for being part of the educational model of integral formation.

The present study gives as evidence that engineering students have managed to develop research and lifelong learning capacities in relation to previous years and as a result of this, it is the increase of 6 publications in 2016 to 24

publications by 2017 in the institutional repository of the University.

It was achieved in the students to enhance the capacities for the publication of research articles with evident results in several national and international congresses, achieving by October of 2018 to publish 11 research articles.

The experience of implementing a Training Research system has allowed us to achieve very relevant and necessary learning to continue to improve and innovate with new research methodologies in order to meet the objectives and mission of the university. It is worth highlighting the team work of research faculty with engineering students and other specialties, for the development of future multidisciplinary work at the undergraduate level.

Our country requires universities to train research engineers, to contribute new knowledge, develop their own technology, as the Universities in Argentina have done with the Open Computer Industrial Argentina (CIAA) project and not only be consumers of information and technology.

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