

Methodological Strategy for the Development of Research Skills in Engineering Students: A Proposal and its Results

Jesús Zúñiga-Cueva and Elizabeth Vidal-Duarte.

Department of Systems Engineer and Informatics
National University of San Agustín. Arequipa-Perú
jzuniga@unsa.edu.pe, evidal@unsa.edu.pe

Arasay Padrón Alvarez.

Reference Center for Advanced Education (CREA)
Technological University of Havana (CUJAE), Cuba.
apadron@crea.cujae.edu.cu

Abstract

The current accelerated social, environmental, economic and technological transformations require higher education to train professionals who respond to these realities, solve problems more quickly and transform society to achieve its survival. On this basis, the National University of San Agustín (UNSA), within the framework of the educational change governed in Peru by University Law 30220, began a process of curricular transformation by competencies, for the continuous academic improvement that is currently claimed. In this context, a proposal is presented on the formation of basic formative research competencies for engineering students, based on the experience developed in the School of Systems Engineering that shows, through two subjects in the first years of studies: Writing of Research Articles and Reports and Research and Writing Methods; the methodological strategy applied and the results obtained.

Keywords

Formative research, Engineering education, research skills, methodological strategy

1. Introduction

Among the changes that are incorporated in the National University of San Agustín (UNSA) of Arequipa, the elaboration of a new Educational Model from the participation of all the actors is highlighted. Model that has made it possible to assimilate international training standards in the formulation of curricular plans, with the aim of international recognition of professional careers. Among the new changes, basic formative research has been incorporated; a process that has allowed the transformation and improvement of the entire curriculum in all careers and programs available to the university.

The constant advances that involve the different fields of engineering, make society and organizations require professionals with increasingly particular skills and emphasized in the development of investigative capacities. This is reflected in the competences that the international accrediting agency ABET (2020) (Accreditation Board for Engineering and Technology) recommends possessing all engineering graduates; Therefore, the concern of study programs is centered on: how to transmit or teach them, recognize their implications for an engineering student, assess the need for their learning and generate actions to achieve the knowledge, attitudes and skills involved in this process teaching-learning.

This work includes the proposal developed in the Professional School of Systems Engineering (EPIS) (2020) of the National University of San Agustín de Arequipa (UNSA) from the application of the curricular changes and improvements developed in the study plan of 2017 to date.

1.1 Objectives

The impact of technological transformations in the area of studies and the training of professionals dedicated to this field; as well as the changes and the university improvement guided the present investigation that is proposed as an

objective: to show the methodological strategy followed for the formation of basic competences of formative research, through two subjects in the first years of training: Writing of Articles and Reports Research, and Research and Writing Methods.

2. Literature Review

Formative research in the curricular and didactic process

Formative Research (FR) refers, in addition to the investigation or intentional search for knowledge or solutions to problems of a scientific nature Tamayo (2002), to the concept of training, to structure something throughout a process. In university education, it encompasses activities aimed at students to understand and develop scientific research; as well as the formation, structuring or refinement of research projects. Miyahira (2012) points out that formative research is fundamental in training for research and for the training of professionals with critical thinking, with the capacity for permanent learning, searching for unsolved problems and proposing solutions in their daily work. He argues that Formative Research requires the university professor to adopt a different stance towards the object of teaching, highlighting the complex, dynamic and progressive nature of knowledge; and in front of the students, recognize and accept their potentialities to assume the responsibility of being protagonists of their learning.

Parra (2004) abounds that formative research and research training must be developed in continuous interaction. Formative research develops in students the abilities to interpret, analyze and synthesize information, and to search for unsolved problems, critical thinking and other abilities such as observation, description and comparison; all directly related also to research training. In this regard, Restrepo (2003) specifies that formative research in higher education addresses the problem of the teaching-research relationship or the role that research can play in learning the same research and knowledge, that is, it is a pedagogical problem and didactic. It also agrees with Muñoz (2015), when he points out that research training can be promoted through the following variants: 1) Subjects that have a curricular space, 2). Carrying out activities that promote the solution to professional situations and problems in each subject, 3). Classroom and level projects, 4). Research hotbeds, and 5). Through internships and bonding periods.

Another important element maintains that research, when oriented to academic and professional training established within a formally defined curricular framework, can be called formative research. This type of research differs in the first place by its pedagogical purpose: to improve the teaching-learning processes; secondly, because it is developed within a specific curricular program where the objects of study are previously determined, and finally, because it can be located within the teaching function of the university professor. Parra (2004).

For his part, Orozco (2016), specifies that in the FR academic hierarchies are recognized within a structure of shared participation in which communication relationships are established that strengthen training. Positions, coinciding or different, must be respected, because they are based on the conceptual and methodological foundation that each participant builds. The FR works in a climate of respect, shared support and generosity in the exchange of ideas, sources of consultation and circulation of knowledge.

The arguments and rationale addressed allow the assumption of formative research as part of the teaching function, with a pedagogical purpose and that is developed within a formally established curricular framework. Therefore, it is possible to interrelate: the teaching function, the curriculum and the research with the students, establishing a formative dynamics of the research from the same activities of the subjects. The FR contains two fundamental differentiated characteristics: it is a research directed and guided by a professor, as part of his teaching function and the research agents are not research professionals, but students in training; For this reason, it is essential that, in order to incorporate this into professional training, both teachers and students have a basic training in research methodology.

Methodological strategy

The process of integrating subjects from basic formative research, part of the didactic conception defended by DC Geary when he points out that: Teachers teach students to self-regulate and actively participate in their learning by setting goals, monitoring and evaluating their progress and exploring their interests to anticipate the basic requirements Geary (1995). Research-based learning strategies originate from the constructivist model and promote an active learning approach Brooks and Brooks (1999), Cobb (1999); the constructivist approach embraces the idea that knowledge cannot be acquired passively. Yager (2000).

Another essential position with respect to the term methodological strategy, assumes the definition of strategy of

Valle (2010) that states “it is a set of sequential and interrelated actions that starting from an initial state (given by the diagnosis) allow directing the step to an ideal state as a consequence of planning”; what is specified in all those actions that from the methodology used can guide the execution of a process, in this case teaching-learning. It is considered that the training process has to take place in all the subjects of a career since, as Rojas(2008) points out, “the preparation of researchers does not focus exclusively on teaching courses on methodology in which research work is carried out”.

The results that are offered through the steps of the methodological strategy are specified in the design of the subjects "Writing Research Articles and Reports" and "Research and Writing Methods". From the acquisition of the initial investigative capacities in the proposed subjects, the students are incorporated into real research teams, in order as De Alba (2003) points out, to carry out tasks according to their training level, capacities and abilities and with a base team responsible for the management of research, which conducts its own research with other students and academics with different educational levels and experiences”.

3. Methods

For the development of the research, the following were used as theoretical methods:

Transit from the abstract to the concrete.- to determine the approach to be used, from the proposals of necessary competencies for the ABET engineering professional, to the diagnosis of the current situation and the particularities of the study program, with the national and international context in which it develops.

Analytical-synthetic.- for the theoretical approach of the basic components that are defended; from the curricular and didactic structuring of the subjects, to the formative research and the characteristics of the methodological strategy.

The modeling.- for the synthetic representation of the subjects and its repercussion in the formation of the basic formative research competences.

Among the empirical methods used, the following are highlighted:

Documentary analysis.- to determine the competences to be developed, the treatment of study plans and subjects and the identification of the methods and procedures to be used to achieve the competencies.

Criterion of specialists.- for an evaluation of the proposal, based on the measurement indicators: current, novelty, relevance, usefulness, feasibility and generalization.

4. Data Collection

Accreditation and investigative competencies

Accreditation seeks to ensure that the institution meets the established quality criteria. ABET (Accreditation board for engineering and Technology), is recognized as an organization dedicated to the accreditation of university education programs in engineering. Criterion 3 of ABET presents eleven educational results that all engineering students must have at the end of their studies (Table 1.).

Table 1. Educational Results of Engineering Graduates. Own elaboration

| |
|--|
| (a) Ability to apply knowledge of mathematics, science and engineering |
| (b) Ability to design and carry out experiments, as well as to analyze and interpret data |
| (c) Ability to design a system, component, or process to meet desired needs within realistic constraints (economic, environmental, social, political, ethical, health, safety, manufacturing and sustainability) |
| (d) Ability to function in multidisciplinary teams |
| (e) Ability to identify, formulate and solve engineering problems |
| (f) Understanding professional and ethical responsibilities |
| (g) Ability to communicate effectively |
| (h) The general education necessary to understand the impact of engineering solutions in the global, economic, environmental and social contexts |
| (i) Recognition of the need and ability to commit to lifelong learning |
| (j) Knowledge of contemporary affairs |
| (k) Ability to use the modern engineering techniques, skills, and tools necessary for engineering practice |

By recognizing the role and importance of established standards, all these skills that have been incorporated into the new EPIS curriculum are worked on. In the case under investigation, the following are particularized: (e) "Ability to identify, formulate and solve engineering problems", (h) "The general education necessary to understand the impact of engineering solutions", and the component (i): "Recognition of the need and ability for lifelong learning". These skills are integrated into the competences of the subjects "Writing Articles" and "Research Reports and Research Methods and Writing", based on their relationship from basic formative research.

4.1 Subject: Articles Writing and Research Reports (RAII)

Actions

4.1.1 Identification of generalizations

Implemented as of 2014 in the new curriculum of the Professional School of Systems Engineering. The course lasts 17 weeks and is taught in the third semester. It has 2 credits and 2 theoretical hours per week. The specific competencies of the course are related to the identification of research topics that solve problems in society, the elaboration of initial drafting schemes, the search, analysis and synthesis of the necessary information, the application of the IEEE / ACM international recommendations of writing and presenting the results of your research in formats: video, poster, oral presentation, among others.

4.1.2 Orientation of semiannual work

To achieve active learning throughout the semester each student writes an article with publishable characteristics, based on a basic research topic given by the teacher. The article only has 6 pages, with a minimum of 20 references. 4 revisions are given throughout the semester. Deliveries are incremental, as shown in Table 2. The guidelines of how to make an outline, where to look for information, how to determine what is relevant, and the rules of writing are taught between the first and third week of classes. From that moment on, the teacher's job is to review each of the advances and provide guidance to each student regarding his writing and discussions about the contribution of his article, until at the end of the semester he exposes his article.

Table 2. Delivery semester work. Own elaboration

| |
|---|
| The Scheme (Drafting Plan) Date: 4th week |
| First Draft: Date: 7th week a) Consider double column IEEE format b) Number of sheets: 2 veneers until the end including the 10 references. c) Starting from the first point of the scheme (Does not include abstract or introduction, or related works) d) Bibliographic References: minimum 10 |
| Second Draft: Date: 11th week a) Number of sheets: 3 textbooks and in the 4th page go the references b) Correction of the comments received in Draft 1. c) Continue with the development of the scheme (does not include abstract or introduction, or related works) d) Bibliographic References: minimum 10 |
| Third Draft: Date: 13th week a) Number of sheets: 5 veneers b) Correction of comments received in Draft 2 c) Includes summary (abstract), introduction and conclusions d) Bibliographic References: minimum 20 |
| Final Article: Date: 15th week a) Number of sheets: 6 veneers b) Same as the Third Draft but having corrected all observations |
| Material: Date: 15th week The student should prepare slides on his subject. (2 or 4 per page) |
| EXHIBITION: Date: 16th week The student will present the topic of his article. The student WILL NOT USE ANY VISUAL HELP. It will be evaluated considering the points explained in class). Exposure Time: 4 minutes |

4.1.3 Determination of the subject of the article

On the first day of school, each student receives the subject of their article. Each topic has been formulated by the professors of the course looking for students to: (a) the mode of action of the career professional, (b) understand the impact of software engineering solutions in a global, environmental and social context, (c) develop critical thinking

and (d) feel motivated and involved with the activities to be carried out from the relationship with their profession.

Some examples of the topics developed in the last semesters were:

- Comparative Analysis of the Use of Augmented Reality for the Teaching of Mathematics in Primary Education: USA and Europe.
- Comparative Analysis of the Use of Augmented Reality in Architecture and Urbanism Projects: Japan and Europe.
- Comparative Analysis of the use of Ubiquitous Computing in Medicine: USA and Latin America.
- Comparative Analysis of the use of Augmented Reality in the teaching of Physics and Chemistry in Secondary Education: USA and Japan.
- Mathematics and Physics behind AngryBirds: as used in secondary education.
- Comparative analysis of the Technology used in Augmented Reality: Software and Hardware.
- Comparative analysis of the use of Alice and Java as the First Programming Language.

4.1.4 Integration of content for basic formative research

The RAI course has the characteristic of having little theoretical content, enough so that students can begin in the basic research process and form communication skills through formal writing and oral presentations. Of the 17 weeks of class, only 4 are dedicated to developing the topics shown in Table 3. In the first two weeks, units 1, 2 and part of unit 3 are explained (up to references and ACM / IEEE citations). In Week 7 the themes of unit 3 are completed and unit 4 is covered.

Table 3. Contents of the course Articles Writing and Research Reports. Own elaboration

| |
|---|
| Unit 1: Introduction |
| <ul style="list-style-type: none"> ● Why do I need to know how to write? ● Why do I need to communicate? |
| Unit 2: Drafting Plan, Information Search and Critical Reading |
| <ul style="list-style-type: none"> ● Drafting Plan: The Scheme ● Information Search: where to look? How do I know it is relevant? Citetex, Indexed Databases: SCOPUS, ScienceDirect, EBSCO, IEEEExplore, IEEE / ACM Publications ● Critical Reading: what is relevant when I read, what information is useful. |
| Unit 3: Writing |
| <ul style="list-style-type: none"> ● Parts of the Article ● Writing rules: paragraphs, sentences, punctuation, musicality. ● Use of graphs, figures and tables. ● References and appointments: IEEE and ACM style ● Abstract, Introduction, Related Works and Conclusions |
| Unit 4. Oral Expression |
| <ul style="list-style-type: none"> ● Mental scheme ● Auditorium management: eye contact, displacement, ● Know how to listen |
| Exhibition Material Preparation |
| <ul style="list-style-type: none"> ● Slides ● Contents ● What to show and what not to show? |

4.1.5 Results Accuracy

Based on the studies proposed by Pimmel (2003), the best way to acquire some skill is (a) provide opportunities to practice the skill, (b) give frequent feedback and (c) have structured discussion activities.

The RAI course provides students with a space to develop these aspects. It is an exercise that starts the process in the research process by having to perform a literature review to develop the outline of the topic to be developed, and also to write about related works. The rigor in the review of the articles, in the validation of the references and in the discussions about them, makes the students aware of the importance of their ethical conduct. Likewise, it is important to highlight that, as the final section of each article, the student must express an opinion on the social and ethical considerations of the assigned topic. This practice seeks to increase the critical and ethical sensitivity of the student.

4.2 Subject: Research Methods and Writing (MIR)

Actions

4.2.1 Identification of generalizations

Implemented as of 2015 in the curriculum of the Systems Engineering degree and as a continuation of the RAI course. MIR has a duration of 17 weeks and is dictated in the fifth semester. He has 2 credits and 3 theoretical-practical hours per week. Following the ABET criteria, the following specific skills are developed in the course:

- e. Acquires, uses and participates in the ability to identify, formulate and solve problems,
- h. Analyze, understand and determine the general education necessary to understand the impact of solutions
- i. Writes, builds and participates in the recognition of the need and capacity of continuous learning.

4.2.2 Orientation of semiannual work

To achieve active learning throughout the semester, work is done individually, prioritizing the theoretical cognitive component and in a group way for practical development. Each group consists of 2 to 3 students. In the first part of the course along with the development of the theoretical component of the research process and its methodology, the development of a research project or plan is pursued; the theoretical sessions are combined with the advice and accompaniment of each group for the formulation of their respective project.

The second part of the course corresponds to the monitoring and development of the research proposal according to the methodological guidelines, concluding in the presentation and support of the final group research report.

4.2.3 Content integration for basic research

The content of the MIR course is detailed in Table 4.

Table 4. Contents of the course Research Methods and Writing.
 Own elaboration

| |
|---|
| Unit 1: The Knowledge Process |
| · General concepts |
| Unit 2: Scientific research |
| · Scientific research, Characteristics |
| · The scientific method, Classification |
| Unit 3: CTI Science, Technology, Innovation and Society |
| · Science, Technology and Innovation CTI |
| · Science, Technology and Society CTS |
| Unit 4: Science and its Method |
| · Scientific Research Methods |
| · Research Classification |
| · Method, Methodology |
| Unit 5: The Research Process |
| · The process of scientific research |
| · Research plan, design or protocol |
| · The Research, Planning and Selection Theme |
| Unit 6: The research problem and the scientific hypothesis |
| · Problem research |
| · Justification and objectives of the Research |
| · Framework |
| · The working hypothesis |
| Unit 7: Research design and methodological aspects |
| · Design and contrast of hypotheses |
| · Data Collection and Analysis |
| · Quantitative and qualitative protocols |
| · Schedule and budget |
| Unit 8: The Scientific Research Report |
| · Investigation Development. |
| · Diagnosis and analysis. |
| · Conclusions and recommendations. |
| · The final investigation report. |
| · Publication and Dissemination |

4.2.4 Integration of the contents for basic formative research in the final research work

The learning of the investigative competence, is reflected from the development of the group project, in which each group proposes a theme. Based on the topic, the development of the research methodology is carried out in each class from the definition and scope of the problem to the identification of the type of research (quantitative / qualitative), scope (exploratory, descriptive, correlational and causal), design of research (experimental / non-experimental), instruments, etc.

Students carry out a reflective process in the development of each class by identifying what applies to each of their projects; Unlike the RAI course where the student receives the subject from the teacher, in this course the students choose the subject according to their interests. Table 5 shows a summary of the work carried out in the previous year.

Table 5. Consolidated MIR work by areas (subjects).
 Own elaboration

| Research areas (subjects) | % |
|-------------------------------|----|
| <i>Classes finished</i> | |
| Web applications development | 28 |
| Human-Computer Interaction | 17 |
| Algorithms and data structure | 6 |
| Requirements Engineering | 6 |
| Operating systems | 6 |
| <i>Subjects not taken</i> | |
| Computer graphics | 22 |
| Database | 6 |
| E-learning | 6 |
| Artificial intelligence | 6 |

100

A relevant aspect shown in the table above is the students' preference for research topics related to subjects already taken or in progress (60%), compared to other more specialized subjects that have not yet been developed.

4.2.5 Results Accuracy

At this level, the initial exploratory proposal embodied in monographic work (RAII) is combined with the implementation of the pedagogical strategy of how to solve problems, through the proper development of the research process. It starts from selecting and identifying specific problems linked to specific areas of career knowledge and prioritizing the lines of research in EPIS activity.

The conceptual contents (know) are emphasized and reinforced with the procedural contents (know-how) and the attitudinal ones, which will guide the development of an effective investigation specified in a final research report. In the absence of a multidisciplinary component, this process is carried out in a group or collective way, which allows distributing the different activities that must be developed, assigning different roles to the members and rotary according to the methodology of collaborative learning, which lends itself significantly to the development of soft and training skills.

It is important to note that the appropriate application and assimilation of the methodological component will be conditioned to the domain of the specific area of knowledge that corresponds to the research work chosen, especially if a descriptive study is intended. Another key aspect to highlight, is presented with the participation of the other teachers of the EPIS who assume the role of specialists and advisors according to their area of specialization or research line; which allows them, in turn, to make contact and select students with a research profile for their research teams.

5. Results and Discussion

Actions

a. Analysis of the strategy based on the Criteria of specialists

For the application of this method, selection criteria were established for the determination of the candidates,

according to the object of the investigation and the interests of the evaluation of the same. It was established as a criterion that they were professionals with experience in the career, who dominate the pedagogy and didactics of the technical sciences, with a scientific category of master and doctor, not less than ten years of teaching experience and not less than five years linked to Education Higher. So that their experience and results in educational direction guarantee the condition of specialists in the subject being studied.

The selected sample consisted of fifteen professionals with more than five years in fulfilling duties in related careers and more than ten years linked to teaching in Higher Education, of which six doctors and nine masters (in Technical Sciences and Education Sciences).

The instrument applied resulted from a process of shaping indicators based on the systematization carried out in the theory about the characteristics and qualities that a scientific proposal must have for the solution of a problem. The measurement indicators decided were: topicality, novelty, relevance, utility, feasibility, generalization and scientific rigor.

b. Analysis of Results

The analysis is carried out from the proposal of the methodological strategy and on the basis of the 7 indicators mentioned above. The results obtained are reflected in Figures 1, 2 and 3 shown below.

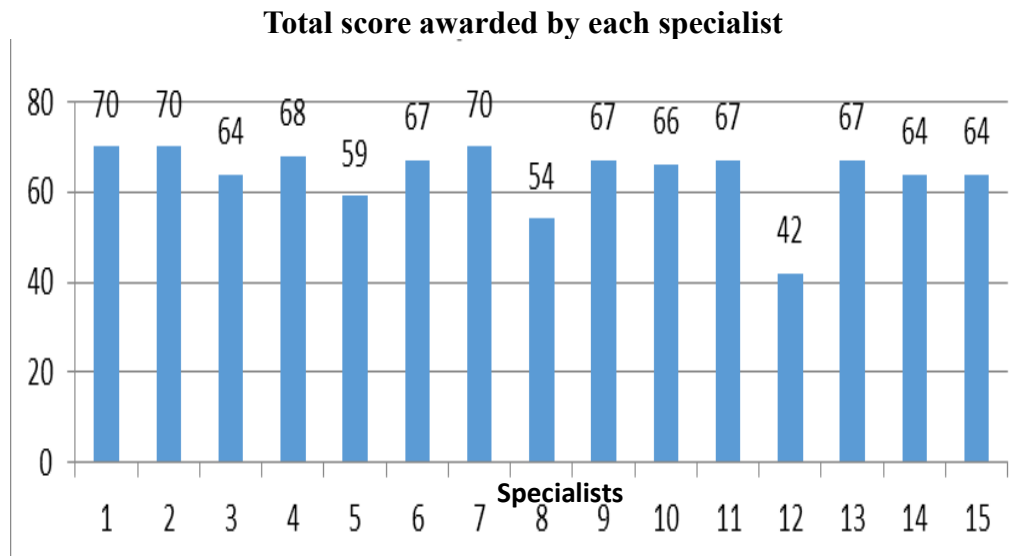


Figure 1. Total Score Source. Own elaboration

In the analysis of the results, it should be noted that the average of the evaluations given to the different indicators is 9.13 out of 10 possible points. The lowest evaluations are located in the novelty, the generalization and the scientific rigor; however, they are considered high, higher than 8.8 out of 10 possible.

According to the evaluation of the specialists, 12 of them (80%) gave scores higher than 64 points out of 70 possible (91.4%). Three of them (20%) awarded scores lower than 60 points, however, higher than 42 points, which represents 60% of the possible points to be awarded; These scores, although correct, are the lowest, they are centered on the possibility of generalization based on the norms for it. In all the results, the importance of the integration of basic formative research in various subjects and the integration of various teachers in the final research work is highlighted.

Reliability was verified by Pearson's correlation coefficient, each indicator was evaluated on a scale from 1 to 10, yielding an average of 9.13 as a result, which indicates a highly reliable correlation. This result means that the specialists give a high appreciation to the scientific proposal that is presented considering that it is highly current. As from the transformation that is taking place in Higher Education, the curricular redesign and the multi and interdisciplinary integration for competency training, particularly the necessary formative research for the solution of current problems, is opportune. It is also novel due to the characteristics of the face-to-face and blended training

that is pertinent and applicable to all engineering careers at the National University of San Agustín (UNSA), adapting its content to the study plan, making it generalizable and rigorous scientific.

Criterion of specialists: average by indicators

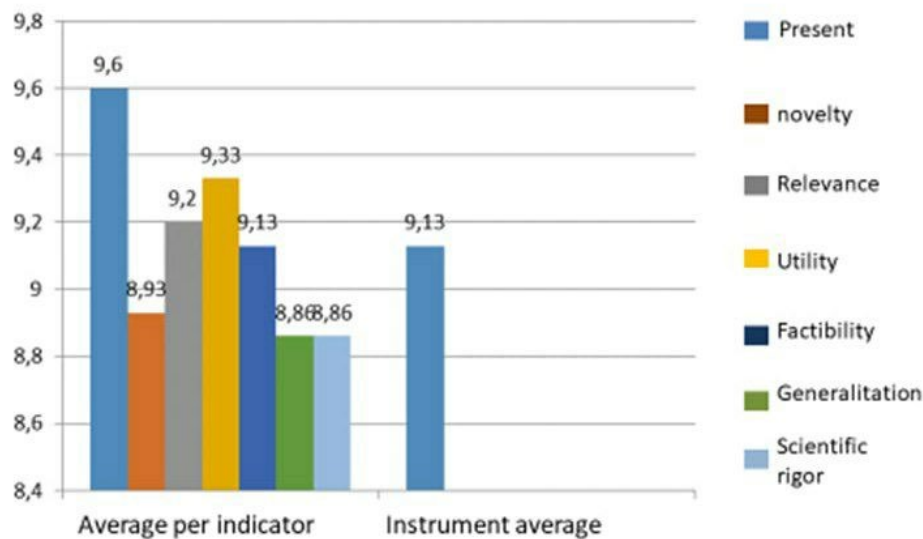


Figure 2. Average by indicators. Own elaboration

Results of the criteria of specialists

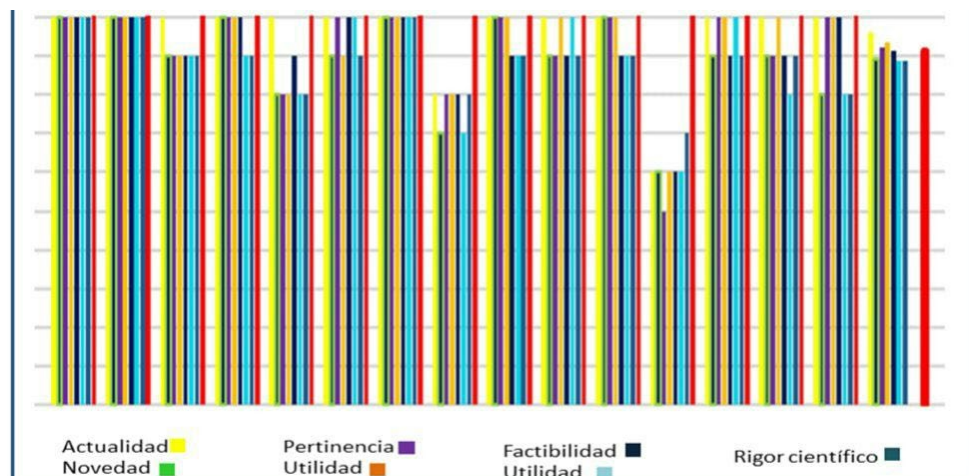


Figure 3. Final Results. Own elaboration

The results obtained from the criteria of the specialists in the valued measurement indicators: current, novelty, relevance, usefulness, feasibility, generalization and scientific rigor; They show in a general way the value of the proposal and reflect the correctness of its selection and development, in response to the transformations of Higher Education today.

6. Conclusions

The mastery of attitudes, behavior and research methodology are essential to develop the final degree projects (dissertations, reports and thesis projects) that are supportive of professional skills. What is derived, to a large extent, from the development of these skills also in the teachers who train them. Cabero-Almenara (2021); Aguiar

(2019).

Given the nature of the subjects that requires a transversal approach, it is important to have a better knowledge base of the career that allows a greater apprehension of the applied content; particularly in the MIR course, which is why it has been considered that it should be located at a higher intermediate level of the curriculum, and in turn, that it is considered a transversal axis in the training of all university students. Cabero_Almenara (2020); Guerra (2019).

Likewise, it is convenient to redefine the number of participating students, in order to enable a more personalized and student-centered academic accompaniment. Bedregal and Padron (2020); Santana and Perez (2020); Hernandez (2019).

In this sense, in addition, the insufficiency of the number of hours assigned per week has been verified, being necessary its increase, with which the efficiency of the teaching work and the fulfillment of the objectives of the subjects from the integration and participation of the teachers who intervene in this year and in this group of students, for the formation of the competences that are oriented from the profile of the graduate. Paz and Padron (2020); Vidal-Duarte and Padron (2020).

There is a tendency to adopt applied research problems and cases, linked to specific practical situations; many of them with multidisciplinary content, which requires support and links with an external specialist. The direct participation of EPIS teachers is important, through their role as external consultants specializing in the area, thereby promoting the promotion of student research skills. This own curricular line of formative research is decisive to capture the end-of-degree work, through the Thesis Project and Thesis Seminar subjects developed in the last year of professional training and which are included as a terminal component of the study plan; which support and allow the obtaining of the academic degree and the professional qualification.

In the exposed analysis, the methodological strategy followed for the formation of basic formative research competencies is evidenced, through two subjects in the first years of training: Writing of Articles and Research Reports and Research and Writing Methods. The results obtained, as well as their validation through the use of scientific methods, allow to demonstrate the fulfillment of the foreseen objective; since it shows the methodological strategy and its scientific evaluation followed for the formation of basic competences of formative research in the first years of university training in engineering careers.

References

ABET, <http://www.abet.org>, 2020.

Aguiar, O., Velásquez, R., Aguiar, J., Teacher's innovation and the use of ICTs in the Higher Education. *Revista Espacios*, no. 40, pp. 8-20, 2019. Available: <https://www.revistaespacios.com/a19v40n02/19400208.html>

Bedregal, N., and Padrón, A., Design of cooperative activities in teaching-learning university subjects: Elaboration of a proposal. *International Journal of Advanced Computer Science and Applications*, no. 4, pp.331-338, 2020.

Brooks, J. and Brooks, M., In search of understanding: The case for constructivist classrooms, *ASCD Association for Supervision and Curriculum Development*, 1999.

Cabero-Almenara, J., and Palacios-Rodríguez, A., The evaluation of virtual education: e-activities. *RIED Iberoamerican Distance Education*, vol. 24, no. 2, pp. 169-188, 2021.

Cabero-Almenara, J., Barroso-Osuna, J., and Palacios-Rodríguez, A., Digital competences of educators in Health Sciences: Their relationship with some variables. *Journal of Medical Education*, no. 22, pp. 94-98, 2021.

Cobb, T., Applying constructivism: A test for the learner-asscientist. *Educational Training and Development*, no. 47, vol. 3, pp. 15-31, 1999.

De Alba, A., Philosophy, theory and field of education. National and regional perspectives, *Educational Research Collection COMIE Mexico*, vol. 11, 2003.

Geary, D., Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction, *American Psychologist*, no. 50, pp. 24-37, 1995.

Guerra, R., Ramos, F., and Jaya, A., Methodological work and scientific writing in the development of the teaching career. *Revista Atlante: Education and development notebooks*, vol. 1, pp. 103-113, 2019. Available: <https://luz.uho.edu.cu/index.php/luz/article/view/957>

Hernández, R., et al., Information and Communication Technology (ICT) and its Practice in Educational Evaluation. *Propós. Represent*, vol. 7, no. 2, 2019, Available: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S2307-79992019000200001&lng=es&nrm=iso

IEEE/ACM, Computing Curricula 2005 – The Overview Report, *Association for Computing Machinery*, vol. 38, no.

- 1, 2006.
- Miyahira, J., Formative research and research training at the undergraduate level, *Herediana Medical Journal*, vol. 20, no. 3, pp. 119, 2012.
- Muñoz, D., The research training of the engineering student. *Electronic Magazine Training and Educational Quality REFCaE*, ISSN 1390-9010, 2015.
- Orozco, B., Narrative configurations in the field of educational research, *Curriculum and XXI Century Seminar* Seminars and academic networks, Barcelona: Octahedron, 2016.
- Parra, C., Notes on formative research. *Education and Educators*, no. 7, pp. 57-77, 2004. Available in: <https://www.redalyc.org/articulo.oa?id=83400707>.
- Paz, I., and Padrón, A., Curricular transformation by competencies: a proposal from the integration and participation of teachers. *Pedagogical Reference*, vol. 8, no. 2, pp. 235-250, 2020.
- Pimmel R., Student learning of criterion 3(a)–(k) outcomes with short instructional modules and the relationship to bloom's Taxonomy, *Journal of Engineering Education*, vol. 92, no. 4, pp. 352-359, 2003.
- Professional School of Systems Engineering*, Available: <http://fips.unsa.edu.pe/ingenieriadesistemas/>, 2020.
- Restrepo, B., Formative Research and Productive Knowledge Research at the University, *Nomads*, no. 18, pp. 195-202, 2003.
- Rojas, R., Training of educational researchers. A research proposal, *Plaza y Valdés S.A. de C.V Mexico*, 2008.
- Santana, JS., and Perez-i-Garcias, A., Co-design of educational situations enriched with ICT. *EDUTEC. Electronic magazine of educational technology*, no. 74, pp. 25-50, 2020, Available: <https://www.edutec.es/revista/index.php/edutec-c/article/view/1799>.
- Tamayo, M., The process of scientific research, *Limusa Mexico*, 2002.
- Valle, A., Some scientific pedagogical results. Ways to obtain it, *Central Institute of Pedagogical Sciences. Ministry of Education Cuba, Havana City*, 2010.
- Vidal-Duarte, and E., Padrón, A., From the diagnosis to the profile by competences: lessons learned in Systems Engineering. *Pedagogical Reference*, vol. 8, no. 2, pp. 267-286, 2020.
- Yager, R., The constructivist learning model, *The Science Teacher*, vol. 67, no. 1 (1), pp. 44-45, 2000.

Biography

Jesús Zúñiga-Cueva is Principal Professor at the San Agustín National University (UNSA), Arequipa, Perú. Mr. Zúñiga studied undergraduate degrees in Industrial Engineering and Economics at this University. He completed a Master's Degree in Production Engineering and a Doctorate in Production Engineering, in agreement with the San Agustín National University and the Federal University of Santa Catarina, Brasil. (UNSA-UFSC). He's the current Director of the Academic Department of Systems Engineering and Informatics at the Universidad Nacional San Agustín. He develops his academic activity in the areas of computer management, information systems, e-learning, entrepreneurship and formative research. Professor Zúñiga is involved in management and social responsibility activities in public sector institutions.

Elizabeth Vidal-Duarte is Principal Professor at the San Agustín National University (UNSA), Arequipa, Perú. She is Systems Engineer from the Universidad Católica Santa María, Arequipa, Perú. Master in Economics – Finance of the National University of San Agustín. She has studies in Software Verification and Validation Studies at National University of Singapore; Formal Methods Studies at the International Institute for Software Technology, Macao, China. She's visiting professor at Clayton State University, Atlanta, Georgia. She works as a Consultant in Business Process Management (BPM) and Business Process Modeling Notation (BPMN). She's a researcher on issues of improving the teaching / learning process with the use of ICT and the game-oriented approach for teaching the first programming courses. He is currently working on accessible technology research for improvements in orphan diseases aimed at neurological problems in children. Member of the IEEE Women in Engineering, IEEE Education Society and IEEE Professional Communication Society. Since 2015, she has been doing empowerment mentoring work for more women in the software area through assistantship programs, and through the creation of communities and undergraduate support networks aligned with the UNESCO 2030 agenda.

Arasay Padrón Alvarez, Professor, Doctor in Pedagogical Sciences, Graduate in Education, Researcher at the Reference Center for Advanced Teaching (CREA) of the Technological University of Havana "José Antonio Echeverría" (Cujae). He directs Science and Technology and the Scientific Council of CREA, Coordinator of the Doctorate in Higher Education of La Cujae, CREA and its Doctoral Committee. Member of the Scientific Council and of the Commission of Scientific Degree (CGC) of the Cujae. Expert of the External Evaluation Commission in

the Doctoral Program Accreditation process of the National Accreditation Board (JAN). Member of the Network of Centers for Higher Education Studies and the Network of Strategic Management in Higher Education. Coordinate and participate in various international events. Directs and participates in various research projects. He is a referee and has published in numerous impact magazines. Professor and coordinator of various subjects and undergraduate, postgraduate, diploma, master's and doctorate courses. Member of the Association of Pedagogues of Cuba and of the Association of Cuban Psychologists. Research lines, Pedagogy and Didactics of Higher and Postgraduate Education with a high presence of ICT, Curricular Theory, Creativity and Values.