Using Research projects in the classroom to improve Engineering education

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Abstract— **Engineering schools and colleges have the challenge of training engineers for the future, who, in addition to excel in the discipline's own technical skills, must be innovative and capable of working in a globalized and changing economy. The scenarios that are glimpsed, require the engineer to have specific competences that must be developed in their training process.**

Proposals such as the 2020 engineer suggest, among other things, that engineering education must be transformed to help achieve the vision and to develop innovations in, hitherto, unknown fields for engineers. Higher education challenge in engineering is to train students to become modern and effective engineers capable of participating and leading conception, design, implementation and operation of systems, products and projects. For this, the students must not only be prepared technically, but also be socially responsible and have the capacity to be innovating permanently. Modern engineering projects require a combination of several disciplines, so engineering schools must incorporate them into existing programs and through activities outside the classroom.

Additionally, research as the basis of teaching and training allows the teacher to leave aside the role of passive mediator between theory and practice. One of the methodologies for carrying this out is the classroom research project with students. This didactic strategy aims at producing changes in the professor's paradigms, passing from passive methodologies to active and constructivist pedagogical practices in the classroom.

This paper presents the experiences of the professors of the College of Engineering and Basic Sciences of Politécnico Grancolombiano using research projects in the classroom. They show that altering classroom situations encourage meaningful learning for students, supports quality education and foster on the professors the development of, among others, pedagogical, technological and communicative, competences.

Some research projects done by students in their in the classroom are: Crutches designed with a weight dampening system in the technical design area; Technical requirements for the design of a food packaging in the industrial engineering program; Electronic Menu (Each table has a tablet that shows the different liquors offered, the customer has the possibility to select the desired one, as well as to make mixtures, at the end the client sends the order, which is received by the person in charge to then be delivered to the client) in the systems engineering program; The manufacture of: Artificial snow, beer, aromatic candles, glue made from gasoline and polystyrene and copper sulfate crystals in the chemistry area; Work in conjunction with the subjects of simulation and stochastic programming to develop a holistic view on the processes in the industrial engineering program, among others.

This paper describes the approach, development and results of research projects used by professors in industrial engineering, systems engineering and systems management technology programs. It shows that the integration of curricular strategies, educational, methodological and evaluation, allow to transform not only classroom practices and academic programs, but also the processes of curricular, teaching and research management. In this way, the professional development of teachers, pedagogic management and the research capacity of the Faculty is strengthened.

Keywords— Engineering Education, classroom research project, engineering schools, methodologies, pedagogical practices.

I. INTRODUCTION

In the last two centuries, human kind has applied fundamental scientific principles and creative thinking to design objects that have produced great advancements all over the world. Keeping this process going and facilitating it is undoubtedly the main mission of teaching engineering. Engineering education, to succeed in this mission, requires that their programs and curricula provide students with the necessary foundation to deduce, analyze, design and invent.

These issues create a huge challenge for curriculum designers. They must come up with an educational plan for undergraduate engineers that is able to meet these aspirations: a balanced study plan that develops the set of skills required by incorporating several components such as the humanities and sciences as well as engineering and current technology. Curriculum designers all over the world are putting great emphasis on producing engineers who, in addition to having the specific technical abilities, are able to meet the demands of today's work environments.

In the same direction, scenario based planning exercises conclude that engineering must: be proactive, have a common vision of an exciting future, transform education to achieve that vision, adjust itself to innovative developments in non-

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engineering fields, and find ways to focus the energies of the different disciplines on common goals. To fulfill this mandate, professors innovate in their classes. By using the proper knowledge management strategies, their achievements and experiences can be replicated by professors in any university that share the same responsibility of training future engineers for solving problems that have not been raised yet.

Additionally, in the current context, engineers cannot work isolated to achieve their goals. Typically, they are part of an organization or members of a team, where they must achieve not only their individual goals and objectives but those of the organization. These objectives and goals can be technical, financial or any other kind, and should be aligned between them. Engineers also have to fulfill their obligations and duties to society, where issues such as safety and environmental protection become important items in the design and inventions that are part of the engineering itself.

The Politécnico Grancolombiano is a University Institution founded 38 years ago in the city of Bogotá, Colombia. It has more than 45,000 students in 101 academic programs of higher education, of which 31 are undergraduate programs in face-to-face and 29 in virtual mode. Through these years, Politécnico Grancolombiano has integrated propaedeutic cycles in its higher education offer, with a clear focus on training in disciplines applicable in business and industry. Propaedeutic cycles is a methodological strategy of the Colombian government to link higher education cycles (technical, technological and professional) with secondary, media and basic education [14].

Politécnico Grancolombiano has its main campus in Bogotá. It has a second campus in Medellín with approximately 1300 students. In this second campus, the Faculty of Engineering and Basic Sciences has programs on Industrial Engineering, Systems Engineering [1] and Technology on Systems Administration.

The Faculty of Engineering and Basic Sciences of the Politécnico Grancolombiano has defined, as an element of the curricular design of its academic programs, the strategy of research projects in classroom. As part of their learning process, students have to do a research work, which is coordinated by the teacher in each course. Students must answer some questions raised by the teacher during the academic term and, based on them, they must plan and develop a project which product is presented at the end of the course in an exhibition where the entire research process is evaluated.

In this paper, we present the experiences of the professors of the Faculty of Engineering and Basic Sciences at Politécnico Grancolombiano using research projects in the classroom. The paper is organized as follows: section II presents a the theoretical framework supporting the use of research projects in classroom in engineering education, section III presents the methodology for research projects in classroom, section IV presents the experiences at Politécnico Grancolombiano, and section V presents the conclusions and future work.

II. TEACHING IN ENGINEERING AND RESEARCH IN EDUCATION

In this section, a brief overview of the theoretical framework that supports the use of research projects in classroom in engineering education at the Faculty of Engineering and Basic Sciences.

Several authors state that engineering professors tend to think that disciplinary research is more important than research in education. The main reasons for this are, in first place, that engineering professors lack of pedagogical education and, in second place, that research in education is done in a mechanical way, without a theoretical support [4]. For research in education it is important for professors to have time for reflection, for making questions and for inquire. At least in Colombia, professors do not have time for that. They invest most of their time in lectures, preparing materials, and advise their students while implementing a defined curriculum, and most professors teach between four and six courses each academic term. Under these circumstances curiosity, creativity and resources are devoted to raise research questions related to the disciplinary area the professor works on instead of focusing on traversal engineering skills that students need to develop [1].

To talk about how engineering education has change through time, it is important to understand its history. Since more than 150 years ago, educational institutions have played a key roll developing engineers' professional skills. During this period, engineering education has been the subject of constant discussions and controversies.

The most important changes have been related to the way engineering education is structured, how it is related to scientific education, and, also, with technology changes and the need for new engineering fields as program-degrees. Despite the history of changes, and particularly despite the controversies at the end of 1960 about the role of engineering education in society, engineering schools and faculties have been amazingly stables regarding their philosophy about the structure and content of engineering curricula [2].

Tensions between theory and practice have appear permanently in engineering education since it was formally established in the XIX century. Scholar in USA have use a pendulum as a metaphor to describe the different priorities in engineering education, ranging from practice to theory. Weichert [3], in a more detailed study, reveals a huge spectrum of positions adopted in engineering schools and technical universities. These positions range from education oriented to practice, skill development and performance, to science based education.

[1] In Colombia, Systems Engineering is an undergraduate program that is a mix of Computer Science, Computer Engineering and Software Engineering.

Engineering in 18th and 19th centuries was based in a vision of technical development and the use of systematic and analytic approaches very similar to the French idea of polytechnique. This idea was developed and promoted by the construction of the Ecole Polytechnique in 1792, starting a new era in civil engineering education. The first professional engineers appear in the 19th century, a time when civil engineering appeared as one the first engineering disciplines. It was developed as an application of the techniques developed by military engineers in the civil society. Military engineers developed techniques for building infrastructure and weapons for war. With the civil engineering, these techniques were applied to build buildings, bridges and roads, and to design mechanical devices that enhanced daily life. These ideas were adapted progressively both in Europa and USA in the first half of the 19th century, leading to create a new kind of higher education institution. At the same time, military schools, like West Point in the USA, were heavily influenced by analytics methods developed from the polytechnique idea.

The practical approach adopted by engineering institutions in the USA and polytechnic institutes in Europe was of key importance for the development and deploying of technology in industries and in the general society. According to Crawley, *these institutions influenced the formation of a professional engineering identity. Although this fact is recognized in contemporary discussions, it is overshadowed by the focus on the theoretical, science-based training that forms the modern ideal of formalized engineering teaching. The tension originates from the creation of an engineering identity where attempts to distance engineers from skilled technicians and their apprentice-based training resulted in a focus on an academic tradition based on the vision of the polytechnic institutions of higher education* [2].

Engineers with academic training were highly regarded for more than 50 years for building infrastructure, and some of these theoretically sound engineers contributed to the development of new inventions in chemistry and electronics. However, by the 19th century, skilled engineers were devoted mainly to industrial development in mechanics and mining. Even in Germany, where universities first offered theoretical education in engineering and the government provided support to the big companies for having research and development centers, the contributions of the engineers to industrial innovation were based in their practical experiences and on systematic tests, and only a small set of the theoretical body of knowledge was applied.

In the 1970s some engineering schools decide to reform the education they were providing. Emphasis was made in the need to solve problems and to project based work to simulate the real working situation the engineer will face at work, but it did not solve all problems they were facing. According to several authors, the answer is in a new comprehension of the role of science in innovation and the use of technology tailored for a specific context. *This approach underlines the existing need to bridge the divide between the disciplinary knowledge of the technical sciences and social sciences, and the practical domains of engineering, with their unique knowledge and routines that integrate the social, practical, and technical aspects of technology at work* [2].

In the decade of 1990, both in the USA and in Europe, questions were raised about the relevance of the engineering education that was provided during the Second World War. They were worried about the lack of practical skills in modern engineering education, the lack of relevance for the industry of the science taught and the kind of analytic qualifications, all these compared with the vision of engineers as creative designers and innovators developing future technologies.

Additionally, contemporary tensions in engineering education can be originated in the diversity of modern technologies, especially when their incorporation in the society requires more qualified engineers every day. This diversity, according to Crawley [2], presents new challenges for defining the main skills and competences an engineer must have. These new approaches acknowledge the role of technology as a factor that contributes to scientific achievements and to change the basic idea of nature and technology itself.

Among several proposals about engineering education worldwide, there is a project named "The Engineer of 2020" [5]. It is an initiative of the National Academy of Engineering (NAE) to predict the roles engineers will perform in the future taking into account a globalized context. This project uses the current reflections about engineering education as its framework and includes two parts: developing a vision for engineering and the work of the engineer in 2020, and examining engineering education and asking what is needed to prepare engineers for the future.

A vision for engineering and the work of the engineer in 2020 was developed in 2002 and they proposed that engineering must evolve taking into account social and technological changes. They also identify the most important technological changes as those related to: high performance computing, biotechnology, logistics and nanotechnology. These are the forces that steer innovation and enable economic growth. Social changes include nations that develop amazing technological capabilities, terrorism threats and an increased industrial productivity.

The project proposes that education for the engineer of 2020 should be centered in undergraduate students but making impact in engineering research and applied research. It must prepare engineers that not only have excellent technical knowledge, but also are innovators that are prepared to work in a global and changing economy.

III. RESEARCH PROJECTS IN THE CLASSROOM

Although there are many reflections and concerns about the education of new engineers and there are different educational models proposed by engineering schools recognized as high quality institutions by global rankings, the scientific community has identified a process which enriches the work of professors, whom are directly responsible to help students develop the skills demanded by the labor market: Scientific research in education [6]. The Committee on Scientific Principles for Education Research [7] of the United States, define this process, initially, from a scientific research perspective. They define it as an approach based in the scientific method, which is defined as a continuous process of rigorous reasoning based in fundamental principles defined by the community of experts.

When the method of scientific research is applied to education, says the committee, its rigor does not guarantee by itself that the results can transform education, but the scientific study contributes to its understanding and improvement. This is the base that supports designing educational research. It considers, mainly, the following dimensions: Methodology development, research design, human nature models, scientific rigor and quality, accumulation of scientific knowledge, and education as an object of study.

On the other hand, the methodology named participatory action research (PAR) is commonly applied in social research. In this methodology, a group of people or a particular community participates in a research trying to solve a problem previously identified as a relevant problem for them [8].

This methodology requires researchers to relate to the target community and to participate in the research in such a way that analysis, theorization and proposal of solutions can be carried out. In this sense, PAR is a form of applied research since it is destined to have some effect in the real world and it is guided by a question that arises from the community interested in the object of research.

When this process of action-research involves teaching processes, it acts as a mediator in students' access to curriculum and to learning. Consequently, to improve the teaching practice it is necessary to consider its processes and its products, in such a way that the processes take into account the quality of the learning outcomes and vice versa.

In this way, the research projects in the classroom developed by the teachers of the Faculty of Engineering and Basic Sciences at Politécnico Grancolombiano, can be viewed from two perspectives: that of the teacher and that of the students guided by the professor.

In the first case, according to the Committee on Scientific Principles for Education Research [7], scientific research in education is the action carried out by professors, either to perfect their teaching, to verify certain postulates of educational theory, or to solve problems related to students. This implies that the professor, by assuming the role of researcher, will carry out educational projects. Also, by promoting critical reflection about the activity as part of the educational practice, this approach will improve the teaching-learning process.

In the second case, Walter [9] points out that participatory action-research in the classroom promoted by the teacher encourages students to develop curiosity, the need to know, to ask, to explore, to check, to experiment, to improve, stimulating the desire to learn in them. This helps to develop the creative and critical thinking of the students so they can have a better performance in their professional life.

IV. PROJECTS DEVELOPED

In this section, we describe some of the research projects in the classroom developed with students majoring in industrial engineering, systems engineering and technology in systems administration. They are presented organized by knowledge area.

Basic Sciences

In the Technical Drawing course, with 19 students, they designed, using SolidWorks, low cost crutches using light materials. The crutches include a system of buffers both at the element of contact with the floor and at the upper support ends, mitigating the forces that generate blistering on the sides of users. It also includes a support system with gel that reduces friction and adapts itself to the shape of the side which provides greater ergonomics and improves patients' health.

This academic term in the same course, with 17 students, they are developing a project that includes the design and the mechanical analysis of a low-cost wheel chair for low incomes people with reduced mobility. To tackle this problem, they are using surveys to understand the experiences of people with reduced mobility that use wheelchairs to identify user requirements and develop a safe, reliable, ergonomic, accurate and economical design.

Not all projects are proposed by the professors. A student, born in Colombia's coffee region[2], proposed a project to improve the design of backpack fumigation sprayers to make it more comfortable and facilitate its use for disinfecting or eradicating pests in coffee crops. It is an innovative design that considers the geometry of the human body to improve posture and prevent possible back pain during the operation. Another goal is to improve air circulation in the back area because operating

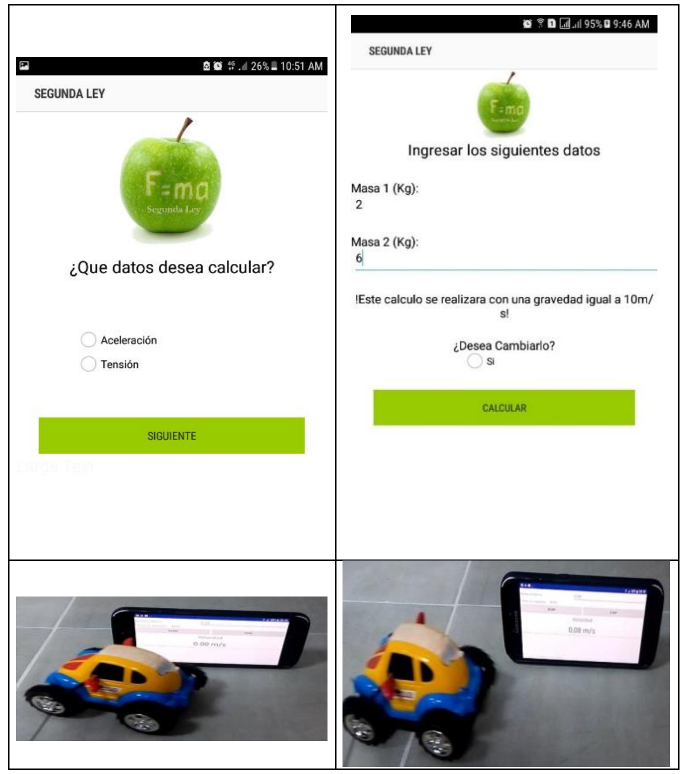
[2] Colombia's coffee region, also known as the Colombian coffee growing axis or the coffee triangle, is a region famous for growing and production of most of Colombian coffee. It includes three departments: Caldas, Risaralda and Quindío.

backpack fumigation sprayers generate great perspiration in that area.

During a whole semester, based in the concepts and skills acquired in the Statistics I course, 43 students from different majors were invited to apply the concepts they learned in the course and do a statistical research project in industry related problems. A survey-type research was carried out, combining all elements and tools of basic statistics, using graphs, statistical measures, basic sampling and probability principles, to solve specific problems in different companies. In all cases the students were working with the same objective: to maximize the benefit of the company when designing and executing plans of action for serving the community of users that relies on it. Due to the different nature of companies, each work was tailored for the specific situation. The work was collaborative, where each member of the research team embraced the tasks of investigating the company, its resources, its history, its actions and the customer service processes, all aiming at optimizing the customer service while creating a better working environment. Each team presented its approach at the end of the academic term making a short presentation and authoring a paper that describes the investigation. It was an enriching experience, not only for each team but for all students in the course and the companies involved in the process. Sharing experiences this way proved to be a good strategy to make all students aware of different real-life situations where statistics can be used. The companies that participated in the process adopted the recommendations made by the teams as conclusion of their work.

In Physics, both static and dynamic, a group of 19 students developed digital resources to be included in *Mega Solver*, a project devoted to provide students with digital tools that allow them to have laboratory activities outside traditional labs. The students develop new android applications: a tool for measuring the speed of a body using a proximity sensor and a tool to visualize Newton laws in linked bodies and free fall. The experience of developing these apps in the course generated deeper learning and motivation to develop quality work and show their value as students. The approach to develop the projects included research activities both in software development and in the discipline and led to an implementation with a programming language that had as a result a fully functional application.

In the Numerical Methods course, students connect theoretical knowledge with practical application. During the academic term, they use commonly available software tools to develop solutions that apply theorical and practical knowledge to solve problems in physics and in science in general. By linking Excel, a software tool available in almost all organizations, to implement different algorithms to find optimal or near optimal solutions to the proposed problems. They work cooperatively to find a solution to the problem and then implement it. At the end of the academic term, they socialize the project by making a short presentation and authoring a short paper that describes the problem, the process and the solution. The work development helped students to understand the connections between mathematical methods and their implementation as algorithms, and to find interesting ways of implementing the solution considering the technical restrictions of the implementation tool. This way, they experienced the link between theory and practice in the solution of real-life problems.



In the course *Chemistry Fundamentals*, students, working in teams, designed different projects applying the knowledge acquired in the course. Each project includes designing a commercial product and a business plan for commercializing it. Some innovative products, created in these projects, were flavored cosmetic petroleum jelly, beet and celery flavored chocolate, fruit flavored salt (mango, watermelon and orange), and scented bath salts.

Industrial Engineering.

In this major, students can select an emphasis, a set of two non-compulsory courses. A project developed in the *Materials Packing and Handling* course is designing a package for formwork structures. The goal of the project was to design and build a packaging system for the building company *Conconcreto*. This company is devoted to the production and commercialization of supplies for construction in five different business lines: aggregates, prefabricated, structural composite panels, formwork and structures. The project is focused on the formwork business line.

Formwork is the name given to temporary or permanent forms or molds in which concrete and similar materials are poured during the construction of various components of reinforced concrete structures - columns, walls, beams, ceilings, etc. It is a material that, due to its importance in the development of a work, covers a considerable percentage of material, becoming one of the largest investments within the budget of a construction project. Having a proper packaging for shipping and handling formwork has a significant impact on cost reduction.

In the Production Management course, the objective of the classroom project is to solve a problem identified by diagnosing the productive process. Each project is developed by a team of students. Each work group must focus on a production process studied in the course and must solve the problem using the tools studied in the course. Student are encouraged to identify additional tools that can be used to solve the problem, by reviewing books, papers, thesis, etc. Using tools learned in other industrial engineering and management courses is also recommended.

As an integral part of the project development, the students, with support from the professor, share with the companies their proposals. This strategy creates the opportunity to contrast the concepts learned in class with the real situations of the productive sector, allowing a direct application of the acquired knowledge.

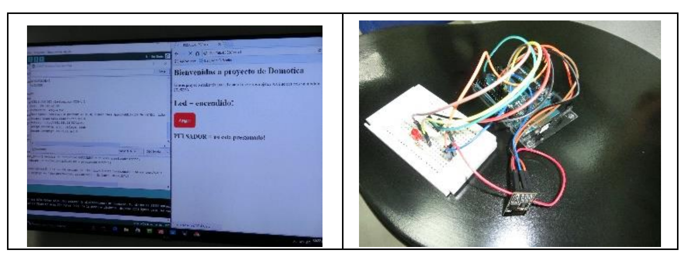
In the Metaheuristics course, the goal was to model problems related with production optimization and to find a good approximation. The students were able to recognize the importance of mathematical modeling for problem understanding and finding a solution. The objective was to make them aware of the difficulty of optimization problems and the importance of the models to solve real problems.

In the Simulation course, the objective of the classroom project was to foster the investigative process of the 30 students. For that reason, authoring a scientific article was proposed as final delivery. Additionally, since all courses in a major share a common goal, this work was proposed in conjunction with students from the Stochastic Programming course so that a holistic view of queue processes and systems and its subsequent simulation was taken.

In the Plant Distribution course, teams are encouraged to make a proposal for redesigning the plant distribution of a company by applying the SLP methodology or any other useful tool for this purpose. They have to design how the plant will be distributed, including the dimensions of each workstation that will be part of the selected operation. In this course, a group of three students proposed a new design for a bakery company that was adopted by the company.

Systems Engineering (Computer Science).

In the course on Digital Systems and Assembler, using Arduino, interesting projects were built. They defined the goal and followed the life cycle of software development from analysis to prototype development. The following projects were developed in this course: Car control using Bluetooth, Embedded Web server for home automation, automatization of a parking lot including visualization of empty places, soap bubbles making machine, lightning control for greenhouses, and a car that autonomously seek heat sources.



Serious games for learning open new ways for understanding complex topics. Mixing serious games with research projects to be developed in the courses was a significative experience in the Software Engineering I and II courses. Initially, students used games like RIVIDOC, a game to simulate the extraction of information from documentaries, and The Semat Game, a game to apply project management. Then, the students developed a game for applying the concepts seen in class. They developed games for learning about programming languages, software development methodologies and project management.

Finally, students in the Project Management course developed projects where they design an innovative product with good commercial perspectives. Two projects were developed. The first one provides a tool for supporting companies in the personnel selection process. The second one, is a tool for managing public space in private condominiums.

V. CONCLUSIONS AND FUTURE WORK

The use of research projects in the classroom is an effective medium to develop practical skills in students. They have been used in different courses with the best results obtained in advanced courses related to the professional practice. The general approach to develop these projects is: to identify a problem, to identify bibliographical references related to the problem o to similar problems, to formulate a researchable question, to define a work plan, to execute the work plan and to communicate the results of the project. As for the learning environments, in classroom projects it is necessary to have learning environments flexible enough to allow team work in the classroom and to reflect the working environment the future engineer will find in his professional activity.

The role played by the professor in the development of the project is fundamental. Although the professor is not the exclusive leader of the activity, he helps each team to organize and plan the development of the project. This is a complex didactic activity which generates a greater commitment. This is the main reason why project work requires a professor who is conceptually trained and who also cares of preparation and didactic planning.

Finally, as said before, research projects in the classroom strategy have been successful specially in advanced courses. Now the idea is to create a hotbed of research[3] and to strength ties with private and public companies to support the development of bigger projects that emulate closely real world working conditions.

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REFERENCES

[1] Shavelson, R. (2002). Scientific research in education. (R. J. Shavelson & L. Towne, Eds.). The National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=10236

[2] Crawley, E., Malmqvist, J., Ostlund, S., & Brodeur, D. (2014). Rethinking Engineering Education: The CDIO Approach (2nd Ed., p. 319). Springer.

[3] Weichert, D., Rauhut, B., & Schmidt, R. (2010). Educating the Engineer for the 21st Century (1st ed., p. 327). Springer

[4] Shavelson, R. (2002). Scientific research in education. (R. J. Shavelson & L. Towne, Eds.). The National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=10236

[5] Engineering, N. A. of. (2005). The engineer of 2020: visions of engineering in the new century. The National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=10999.

[6] Shavelson, R. (2002). Scientific research in education. (R. J. Shavelson & L. Towne, Eds.). The National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=10236

[7] Página Web: http://www.nap.edu/

[8] Walter, M. (2009). Participatory Action Research. Social Research Methods. Retrieved from http://www.oup.com.au/__data/assets/pdf_file/0003/198228/WAL_SRM2_ORC_21_3pp.pdf.

[9] Wiles, Jon. (2005). Curriculum essentials (2nd ed.). Estados Unidos: Allyn & Bacon.

[10] Tyler, R. W. (1969). Basic Principles of Curriculum and Instruction (1st ed., p. 134). University Of Chicago Press.

[11] Marsh, C. J. (2009). Key Concepts for Understanding Curriculum (4th ed., p. 224). Routledge.

[12] Centre, I. D. R. (1997). Nurtured by knowledge learning to do participatory action- research. (N. A. Smith, Susan E; Willms, Dennis G; Johnson, Ed.). Apex Press.

[13] Bueno, Natalia. (2014). Un modelo de innovación en diseño curricular para la enseñanza de la ingeniería en la Universidad EAFIT. Universidad EAFIT.

[14] Alfonso Pérez Gama, Byron Alfonso Perez-Gutierrez, Guillermo Hoyos Gomez, "Knowledge for society the social inclusion towards the high educational competitiveness: A knowledge-based governability model for the Higher Education in Colombia by Propaedeutic Cycles", *Global Engineering Education Conference (EDUCON) 2011 IEEE*, pp. 1139-1145, 2011.

[3] In the Colombian context, a hotbed of research is a group of students leaded by a professor that meet regularly to develop research skills while developing research projects.