

## Learning through projects in the training of biomedical engineers: an application experience

This article has been downloaded from IOPscience. Please scroll down to see the full text article.

2011 J. Phys.: Conf. Ser. 313 012014

(<http://iopscience.iop.org/1742-6596/313/1/012014>)

View [the table of contents for this issue](#), or go to the [journal homepage](#) for more

Download details:

IP Address: 200.126.186.85

The article was downloaded on 14/11/2011 at 00:26

Please note that [terms and conditions apply](#).

## Learning through projects in the training of biomedical engineers: an application experience

**José Antonio Li Gambi and Carmen Peme**

Facultad de Ciencias Exactas, Físicas y Naturales. Universidad Nacional de Córdoba. Argentina.

joseeligambi@hotmail.com

**Abstract.** Learning through Projects in the curriculum consists of both the identification and analysis of a problem, and the design of solution, execution and evaluation strategies, with teams of students. The project is conceived as the creation of a set of strategies articulated and developed during a certain amount of time to solve a problem contextualized in situations continually changing, where the constant evaluation provides feedback to make adjustments. In 2009, Learning through Projects was applied on the subject Hospital Facilities and three intervention projects were developed in health centers. This first stage is restricted to the analysis of the aspects that are considered to be basic to the professional training: a) Context knowledge: The future biomedical engineers must be familiarized with the complex health system where they will develop their profession; b) Team work: This is one of the essential skills in the training of students, since Biomedical Engineering connects the knowledge of sciences of life with the knowledge of exact sciences and technology; c) Regulations: The activities related to the profession require the implementation of regulations; therefore, to be aware of and to apply these regulations is a fundamental aspect to be analyzed in this stage; d) Project evaluation: It refers to the elaboration and studying of co-evaluation reports, which helps to find out if Learning through Projects contributes to the training. This new line of investigation has the purpose of discovering if the application of this learning strategy makes changes in the training of students in relation to their future professional career. The findings of this ongoing investigation will allow for the analysis of the possibility of extending its application. Key words: engineering, biomedical, learning, projects, strategies.

### 1. Introduction

The project is conceived as the creation of a set of strategies articulated among them chronologically, with the purpose of solving a contextualized problem (question, new knowledge, method application) in a dynamic and ever-changing network of situations, in which there is a continuous evaluation that provides feedback and allows us to make the necessary adjustments.

This teaching strategy known as the Project Method has its origin in Kilpatrick's works [1]. Within the curriculum, it constitutes a teaching model focused on the students, who plan, implement and evaluate projects of real world application, beyond the classroom, through activities of interdisciplinary teaching in the long term. The strategy helps to create experiences which turn the learning activity into a process whose purpose is to facilitate knowledge acquisition and the development of theoretical productions, interpretations and contextualized practices. According to the author, the method has four stages: Goal setting, planning, execution and assessment (set the project's goals and objectives; create a plan of tasks and time frames; put it into practice; evaluate the outcomes

and draw conclusions). To deal with these situations, the students should apply what they learn in order to solve such situations or suggest improvements in the communities where they take place.

The purpose of the project is not only to learn about something, but also to do something, which implies to acquire knowledge and develop specific skills and a cooperative attitude. In the project, we think about something that does not work well or that could work better, we suggest and evaluate solution alternatives and then we put into practice the one we consider to be the best, taking into account the optimization of costs and time, the maximum exploitation of the resources at stake, and the socio-cultural, environmental and economic impact of the project from the beneficiaries' and potential affected people's point of view. The situations dealt with are changing constantly and there is a continuous evaluation, which provides feedback to make the necessary adjustments [2].

Learning through Projects has evolved from the constructivist theories of learning that belong to Vygotsky, Bruner, Ausubel and other theorists of learning and teaching.

Vygotsky has confirmed through his studies that students better develop their educational processes as they have much more experienced collaborators who allow them to make progress through the zone of proximal development (ZPD) [3], [4]. Learning through Projects is intended to work on and expand the ZPD.

Bruner [5] coined the term scaffolding, which defines the way in which an adult collaborates with a student's learning process. Such process is achieved through the interaction between the subject who learns and the context in which they are placed. The teacher encourages the learner to participate actively. From this comes the emphasis he puts on learning through discoveries, which develops in a context that challenges the students and motivates them to solve problems and transfer what they have learned. The teacher will be then the guide in the discovery. In Learning through Projects, the students find motivating projects in which they play an active role.

García Madruga [6] points out that the students discover the material before they can assimilate it. The students reorganize this material, adjust it to their previous cognitive structure and discover the relationships, laws or concepts that they later assimilate achieving what Ausubel calls significant learning. Learning through Projects has as its purpose to make the students learn deeply and develop specific methodological and social competencies that enable them to act in a competent way in social and work situations.

The teacher's role is to act as a facilitator, a guide, a mediator, a strategist and a negotiator, promoting an atmosphere of participation and cooperation. The teacher interacts with the teams, observes, listens, asks, answers, offers suggestions and stimulates the students' individual and group thinking. They allow the students to behave freely, but they also establish limits, keep expectations and provide guidance for the search of what is essential to know, discuss and shape.

Learning through Projects is a comprehensive methodology that consists of a wide scope of different teaching and learning strategies. If we work with one or more of these strategies, we will create an environment favorable for deepening knowledge and developing competencies and attitudes of all the participants.

In Learning through Projects, the stage in which we evaluate the learning process of the students is very important. In this stage several procedures can be used to determine the achievement of the goals set: a) The initial evaluation allows to diagnose the students' previous knowledge; b) the evaluation based on performance makes it possible to assess the willingness and the learning processes in a specific stage, and to make the necessary adjustments to the educational project; c) the evaluation based on tests or exams helps to estimate the level of the knowledge acquired; d) the auto-evaluation report, oral and written, allows the students to make their own assessment of what they have learned; and e) the evaluation of the project's progress reports helps to assess the improvements the students make and the concepts they learn.

It is necessary that all the projects have one or more public presentations on progress to evaluate the process and the work product in an individual and group manner. This gives the students the opportunity to show what they have learned and increase the validity and authenticity of the evaluation of the prepared project. The progress signs and the medium-term results allow thinking and self-

criticism, which can be used to detect problems, analyze difficulties, measure progress and, if necessary, redirect it upon a base of follow-up revisions. However, when the project finishes, we should think about its successes and failures, and the new strategies and actions to adopt in future projects.

## 2. Background data

The search for background data referred to theoretical frameworks, foundations and a description of the methodology.

In addition, this showed a breaking up in the conceptions about Learning through Projects and the domain in which it is applied. We can find application experiences in school projects (research, technological, social, etc.) in the different levels of the compulsory education (La Cueva [7] and [8], Restrepo [9], MECDV [10] and Castillo Cortés [11]). In the scope of higher education and, more specifically, in professional training courses, the number of works is reduced. The Instituto Tecnológico y de Estudios Superiores de Monterrey ITESM [12] has a significant role as regards this. Application works of Learning through Projects in Biomedical Engineering or in similar courses of study were not found.

This led to an exploratory research with the students that took the subject Hospital Facilities in 2008. Learning through Projects was applied to the topic Medicinal Gases (three units of the program). In the field, it was possible to analyze the development of the method, the students' receptivity, the impact on their learning processes and the difficulties encountered when this project was included in a regular four-month period together with other responsibilities of the students. In this study, aspects to be worked upon were identified, since they would modify the course of study.

## 3. Context

Strengthening a process started more than 20 years ago with the creation of the Laboratory of Applied Research and Development (L.I.A.D.E.), the Faculty of Exact, Physical and Natural Sciences incorporated Biomedical Engineering to its educational offer. This course of study started to be taught in 2004. The current curriculum (2005) is the result of a joint initiative between the Faculty of Exact, Physical and Natural Sciences and the Faculty of Medical Sciences of the National University of Cordoba (UNC).

Biomedical Engineering is a branch of Engineering, which connects the knowledge of sciences of life with the knowledge of exact sciences and technology, with the purpose of preparing a professional who can work and investigate in the medical and other systems. The graduates will have knowledge of electronics, mechanics, materials and computing; they will also be familiarized with the structure and functioning of hospital systems, which will enable them to suggest solutions to problems related to health prevention and care for the population. The graduates must be able to: a) Design and use sets of instruments of high-complexity technology of biology and medicine, and advise on their use; b) apply the methodology of scientific research to studies within their scope of knowledge; c) participate in the creation of asepsis and safety conditions through the application of measure and radiation equipment; d) collect data for the diagnosis of biological systems through electronic, mechanic, acoustic and optical procedures; e) develop, create and evaluate assistive devices for disabled people; f) study biological systems to develop technological applications; and g) combine multidisciplinary health, research and development equipment.

The curriculum includes four blocks: a) Basic sciences (contents of mathematics, physics, chemistry, biology, computing and design); b) basic technologies (contents of numerical methods, electronics and theory of signals, and specific material of the course of study, such as biomaterials, transducers and sensors); c) applied technologies (contents that constitute the technical knowledge of the course of study and that apply to hospital facilities, biomechanical and biomedical sets of instruments, rehabilitation engineering; the supervised professional practice and the integration project are also included); d) complementary subjects (related to humanistic and philosophical education of the engineer, English and Portuguese as optional subjects, and contents related to management).

To offer the educational service of the subject Hospital Facilities, the coordination department of the School of Biomedical Engineering entrusted the teaching of this subject to the area of Building Facilities and Networks of the Department of Civil Constructions. The subject is developed in the seventh four-month period; that is to say, in the fourth year, with a hourly load of 6 hours per week, a total of 96 hours of classroom activities and a similar quantity of study load and activities not developed in the classroom. In order to register for this subject, students must have passed, or at least have taken, the subjects belonging to the basic technological block, since these will help them to deal with its contents. Given the characteristics of the course of study, the majority of the students are full-time students; a very small percentage of them perform other activities.

#### **4. Definition of problems**

Once the background data of the different subjects had been analyzed and the students that took Hospital Facilities had been inquired, it was deduced that Learning through Projects was not used as a strategy during the course of study; therefore, it is not known if its application generates changes in the students' learning, which then could impact on their professional career.

It is important to point out that, in this first stage, the aspects to be studied are limited to the ones considered to be essential for the professional training in this area: a) Knowledge about the context in which the graduates will have to work to be able to develop successfully their profession; b) the specific regulations used; c) team work; and d) the elaboration of reports on the co-evaluation and its subsequent study. Other aspects can also be the subject of new works.

Furthermore, it should be emphasized that this study is restricted to the person to whom the instruction is intended. In further investigations, the subject of study will be the teacher's role, the role of the institution, etc.

According to what was indicated in this study, the following problems are dealt with: 1) Do the group of students who took the subject Hospital Facilities in the first four-month period of 2009, during which Learning through Projects was used, improved their skills in relation to the description they made of the context in which they developed specific projects? 2) Do they make progress as regards their favorable attitude to team work? 3) Do they deepen their knowledge and improve the application of the regulations related to specific projects? 4) Do they master their skills to evaluate projects?

#### **5. Application of Learning through Projects**

During the first four-month period of 2009, the 33 students that took Hospital Facilities developed Learning through Projects in three projects which, due to the objectives of the course of study and the scope of the university degree, were treated as intervention projects. The topics developed in the projects were the following: a) fuel gas facilities, b) protection of human beings; fireproof facilities, and c) medicinal gases facilities.

The course was divided in nine work teams, and each team was assigned a health center to visit. For the first project, nine small buildings were chosen: Primary health care facilities, dependent on the Department of Primary Health Care of the Town Hall of the City of Cordoba. For the second project, medium-sized buildings with several medical specialties were chosen, such as clinics that depended upon the same municipal establishment. The last project was developed about big buildings; in this case, the following hospitals were included: Hospital de Niños Santísima Trinidad, Hospital Pediátrico and Hospital Materno Neonatal, dependent upon the Ministry of Health of the Province of Cordoba.

In the projects, the teams had to be aware of the documents that define the provisions and regulations related to the specific facilities of each case. Then, by going to the health center and gathering data about it through records and surveys they considered necessary, they were also able to be in contact with the contexts, the functioning of the health center and the people who work or require medical assistance there.

With the records and data collected, they had to do an analysis of the applicable regulations, and then they had to make an intervention project on the health center, and assess the interventions in the

following ways: Urgent, necessary, and desirable. All the information was compiled in one report presented to all students and teachers. The report had to contain, at least, an introduction, which depicted the health center, a description of the current situation in relation to the applicable regulations, and the intervention project.

The oral presentation of each project by the teams also enabled the entire class to be informed about the health center visited and the special characteristics of each case.

For explanatory purposes, two of the developed projects are detailed below:

1.- Team n.º 5, which consists of three students, was assigned Health Center n.º 7, "Pueyrredón". There they had to develop the first intervention project about fuel gas facilities. In their work, they made an introduction to describe the establishment, its dependency, the services provided and the infrastructure it had. Then they made a detailed analysis of the center and verified the compliance with the applicable regulations, in this case, NAG 200. The report finished with the following description: a) Necessary interventions: Correct installation of heating systems in the respective walls and the installation of air intake lines and gas exhausting systems of vent-heaters; b) necessary interventions: Correct installation of pipes, lining of pipes which are outdoors, and installation of ventilation lines and caps for cookers and storage water heaters. At the presentation, the participants expanded the written report and made comments about the special characteristics of the health center in relation to its usefulness for the community.

2.- Team n.º 8, which consisted of three students, was assigned UPAS N° 1, "San Roque". There they had to develop the second project on protection of human beings and fireproof facilities. They carried out the project answering the instructions given and providing a description of the health center, the services provided and the area covered. Then they made an evaluation taking into account the subdivision of the building, fireproofing of its materials, fire exits, fire conditions, and equipment necessary for extinguishing fires. On their final report, they rated the facilities as adequate and optimal, but they pointed out that the fire extinguishers had to be placed in the correct location, since at that opportunity they were kept in a warehouse.

## 6. Preliminary results

Since this work is limited to the aspects related to the students' learning about the problems pointed out in point IV, the submitted reports were analyzed and the following was evaluated: a) Description of the context through the inclusion of: The place occupied by the health center in the health system, dependency (government level and inside the level Secretary, Department, etc), services provided, community served: Consultations, neighborhoods or areas it serves, socio-economic characteristics of the population; b) team work: The opinion the student had about their work in the project and the opinions of their classmates; the students were asked to complete a chart individually with their own pen name and the one of their classmates (in order to keep the confidentiality of the information), and to rate four analysis categories in a five-point scale: The search of information, role assigned, timely delivery of material prepared, and participation in the report discussion and elaboration; c) as regards the knowledge and application of the specific regulations, certain analysis categories were established in relation to the project. The results for the first and third project were the following: Supply, pipes, devices and facilities, and for the second, presence or absence of the corresponding elements; d) for the projects evaluation, each team was asked to assess the rest of the teams, as regards both the written report and the presentation of the project, previously indicating the evaluation criteria to be used and the reasons of their choices.

The preliminary analysis of the information collected made it possible to identify some progress in the description of the context in each project, an increased participation and commitment to team work, and a very good management of the regulations and their applications.

## 7. Preliminary conclusions

As regards the application of Learning through Projects, the following conclusions were drawn: a) Important negotiations are required in order to obtain the authorizations that would allow the teams to

enter the health centers; b) some problems can arise as the ones occurred with the third project, in which three teams could not visit the hospitals in one occasion due to the social conflicts originated by municipal complaints, and in another opportunity it was considered to be risky that the students enter a hospital due to the influenza A virus; c) the work through projects requires time outside the classroom, and students find it difficult to combine it with the demands for other subjects; and d) students believe Learning through projects is very positive, since it helps them to work in an environment with which they will be in contact during their professional career.

It is relevant to point out the impact this project had on the context of some health centers of the Province of Cordoba. At the moment of selecting the staff to gather data about the medicinal gases facilities, the company in charge of maintenance of medicinal gases facilities in public hospitals established certain selection criteria: the task must be performed by students of this course of study, these students must have taken this subject, they must have applied Learning through Projects, and they must have obtained a very good final grade. Two of the students of this class group were hired for the task.

These conclusions are preliminary and restricted to the aspects studied and to the person to whom the instruction is intended. If we continue with this line of investigation, we will be able to look deeply into other aspects, other roles and the impact of the application of Learning through Projects on the professional career.

### Acknowledgements

To the students of the course of study Biomedical Engineering of the Faculty of Exact, Physical and Natural Sciences, National University of Cordoba, who, in the first four-month period of 2008 and 2009, took the subject Hospital Facilities, for their job and cooperation.

To the engineers Carlos Olmos and Walter Gómez, who facilitated the entry of the students to the health centers, and accompanied them and advised them during their work.

To the authorities, medical teams and technicians of the Department of Primary Health Care, Town Hall of the City of Cordoba, for their willingness to cooperate with the students.

### References

- [1] W. H. Kilpatrick, "The project method", *Teachers college record*, vol. XIX, N° 4, pp. 319-35, 1918.
- [2] C. Peme – Aranega, "Los espacios curriculares integradores en la formación agropecuaria", *Conferencia: 1er. Encuentro. Facultad de Ciencias Agropecuarias*, Universidad Nacional de Rosario, 2007.
- [3] L. Vygotsky, "Métodos en la investigación reflexológica y psicológica", *2º Congreso Panruso de Psiconeurología*, Leningrado, Rusia, 1924.
- [4] C. Coll, *Psicología y Currículo*, Laia, Barcelona, 1987.
- [5] J. Bruner, "The role of tutoring in problem solving", *The Journal of Child Psychology and Psychiatry, Published on behalf of the Association for Child and Adolescent Mental Health*, V 17, I 2, pp. 89 – 100, 2006.
- [6] J. A. García Madruga "Aprendizaje por descubrimiento frente a aprendizaje por recepción: La teoría del aprendizaje verbal significativo", en Coll, C. *Desarrollo psicológico y educación II. Psicología de la educación*, Alianza, Madrid, 1990.
- [7] A. La Cueva, "Retos y propuestas para una didáctica contextualizada y crítica", *Educación y Pedagogía*, IX(18), pp.39-82, 1997.
- [8] A. La Cueva, "La enseñanza por proyectos ¿mito o reto?", *Revista Iberoamericana de Educación*, N° 16, pp.165-187. 1998.
- [9] A. E. Restrepo, "Estrategias para la intervención pedagógica en los procesos de enseñanza de la escritura y la lectura", *Centro de servicios pedagógicos*, Universidad de Antioquia, Medellín, 2000.

- [10] Ministerio de Educación, Cultura y Deportes (MECDV), “Metodología del proyecto. Renovemos la escuela Básica, Rural, Indígena y de frontera”, *Teoría y praxis*, Venezuela, 2002.
- [11] J. Castillo Cortés, “El Aprendizaje por Proyectos”, *Red Académica* ([www.redacademica.edu.co](http://www.redacademica.edu.co)) *Publicación de Maestros*, Colombia, 2006.
- [12] Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), “El método de proyectos como técnica didáctica”, Dirección de Investigación y Desarrollo Educativo, Vicerrectoría Académica. <http://www.sistema.itesm.mx/va/dide/inf-doc/estrategias/>, 1999