Project-Based Learning with historic buildings: immersion in real training environments for the Degree in Technical Architecture

David Villanueva Valentín-Gamazo[1], Nelson Tuesta Durango[1], Francisco García-Herrero[2], Mª Isabel Mansilla Blanco[3], Mª Cruz Rey de las Moras[1]

dvillanueva@uemc.es, ntuesta@uemc.es, francg18@ucm.es, mimansilla@uemc.es, mcrey@uemc.es

[1]Technical Teaching Department
European University Miguel de Cervantes
Valladolid, Spain

[2]Department of Computer Architecture and Automatics
Computer Science Faculty,
Complutense University of Madrid
Madrid, Spain

[3]Humanities Department
European University Miguel de Cervantes
Valladolid, Spain

Abstract- University education in the knowledge branches of Engineering and Architecture, has usually been based on the system of assignments and projects as a practical dynamic of training and assessment in many subjects. With the EHEA arrival, the search for new complementary systems more focused on learning than on teaching or, in other words, on the student than on the teacher, boosted the commitment to the methodology known as Project Based Learning (PBL), oriented to the development of technical skills in contexts similar to those produced in professional environments. In general, these pedagogical scenarios are built on the basis of theoretical models inspired by real cases to a greater or lesser extent. This paper analyzes the method implemented since the 2017-2018 academic year to innovate in the compulsory subject of Rehabilitation, Restoration and Pathology of the Technical Architecture Degree at the European University Miguel de Cervantes, when the PBL applied in case studies of existing historic buildings; providing students with heritage constructions to visit, recognize, measure, diagnose, draw, rehabilitate, restore, etc., and allowing their immersion in situations that introduce them to their future work practice reality.

Keywords: Technical Architecture, Built Heritage, Project-Based Learning (PBL), Cooperative and Collaborative Work, Immersion.

1. INTRODUCTION

The intervention in historic buildings, whether for rehabilitation, restoration or conservation, requires -in addition to a special sensitivity to preserve our heritage- the adoption of a working system for the definition of the construction project to start the building process with, followed by the construction stage and the subsequent use and maintenance of the building. A cycle marked by the demanding legislation on building, heritage, urban planning, etc., as well as by the client's particular requirements. Developing an action plan of this nature on a building, construction or infrastructure erected in the past differs from the project method of a new construction without the existence of previous architectural constraints. The age of the building, conservation state or heritage value are some of the variables to be considered in the study and technical proposal. Therefore, it is necessary to build an effective and efficient strategy that makes possible the collaboration and cooperation of very diverse agents (technical architects, architects, engineers, historians, archaeologists, topographers, engineers, etc.), in a coordinated group practice capable of aligning different perspectives with a common objective (ICOMOS, 1965 and 2000).

Project Based Learning (PBL) (Heard, 1929) is presented as a kind of active teaching suitable for innovation which might get students of the Degree in Technical Architecture, future professionals in the building sector, to experience and learn the lessons by applying this dynamic to the construction and work planning of the labor scenario, under a precise competency framework's development. Among other models, Challenge Based Learning (CBL), aimed at solving significant problem situations through a challenge, Design Thinking, focused on creating solutions from a designer's point of view, gamification, organized through games, the Inverted Classroom, based on studying at home and working in the classroom, or Cooperative Learning, focused on interpersonal relationships, have certain connections with the methodology used. However, as it is required to draft a construction intervention project on an existing building according to a dynamic similar to that developed in the Technical Architect's profession, we have chosen to place PBL at the center of the pedagogical process as it constitutes a learning model aimed at solving a real action from a multidisciplinary vision, in a collaborative and cooperative manner in groups coordinated by the teacher. (Vicent, 2006). The proposed formative scenario provides that the students interact with the building/construction and actively use the acquired knowledge, but it also seeks to motivate them to investigate new aspects or to inquire more about what they have learned and, very importantly, to share it with teammates and other groups in the classroom, favoring individual and collective meaningful learning (Ausubel, 1983) and to encourage social responsibility, since the object of work exists.

2. CONTEXT

A. Professional

Returning to the symbiosis labor world - academic world exposed above, from the professional practice's point of view, it seems clear that the intervention on architectural heritage must attend to a general method or systemic approach

(González, 1999 and Onecha, 2018), which each technician adapts to the given casuistry as well as to the specific assignment. Agents from various disciplines take part in the process guided and coordinated by the director or main responsible.

B. Educative

In the field of university education, Order ECI/3855/2007, of December 27, 2007, establishes the requirements for the verification of official university degrees that enable the exercise of the profession of Technical Architect, and determines the acquisition of skills linked to specific units of content in the curricula for the Bachelor's Degree in Technical Architecture. Regarding the field of rehabilitation, restoration and pathology, it points out, in the Building Techniques and Technology module, to comply with the following competences:

- Knowledge of the traditional materials and construction systems used in building, their varieties and the physical and mechanical characteristics that define them.
- Knowledge of the historical evolution of construction techniques and elements as well as structural systems which have given rise to stylistic forms.
- Ability to rule on the causes and manifestations of injuries in buildings, and to propose solutions to prevent or remedy pathologies.
- Ability to intervene in buildings' rehabilitation and in restoration and conservation of built heritage.

C. Subject

In light of this labor and training frame of reference, and taking into account the value of placing the students at the center of the educational process, the PBL of intervention in existing historic buildings has been deployed in the compulsory subject of Rehabilitation, Restoration and Pathology of 3rd year of the Degree in Technical Architecture at the European University Miguel de Cervantes (UEMC) since the 2017-18 academic year. The aim was to go a step further than the usual approaches of work and projects on theoretical case studies, in order to generate a real building learning space as a teaching mean. Thus, following one of the active methodological lines promoted by our UEMC Educational Innovation Group (GIE). It should be noted that, despite the impact caused by the coronavirus pandemic on the face-to-face teaching model, the course could be normally taught as it belonged to the 1st semester in the 2020-21 academic year.

3. Description

The teaching system implemented in the subject in order to innovate thanks to the PBL model is structured in a cycle of connected stages (Figure 1):

0. Learning Space.
1. Goals.
2. Groups.
3. Organization.
4. Project phases.
5. Assessment-results.

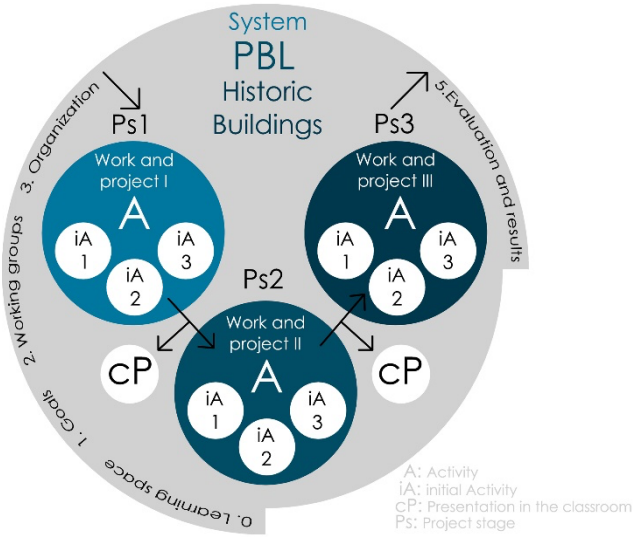

Figure 1. Conceptual scheme of designed PBL method

The core consists of three phases (Work and project I, II and III) composed of activities, driven by initial practices, aimed at intervening in a built architecture (historic buildings) and evaluated by milestones of achievement of results according to the curriculum subject sheet. Then it is explained how the methodological learning cycle is applied.

A. Learning Space

The topic is based on an existing historical building, selected by the teacher according to the objectives and skills developed, paying attention to its location in an area close to the UEMC campus to facilitate the technical visits of recognition, analysis and study.

Likewise, contact with the property is established and adequate access to the heritage site is ensured. Once the learning environment is chosen, the system's tasks are contextualized with a title clearly identifying the object of the work and students are asked the question:

Shall we rehabilitate, restore or conserve?

B. General and Specific Goals

The primary and secondary objectives to be achieved by the group are established in the general statement, offering a global vision of the purpose of the activities integrated in the methodology.

C. Working Groups

With this information -title and initial question- students are distributed in teams the first day of class, either leaving the composition criteria to the students' will or randomly, as agreed by the majority. Once defined, groups cannot be modified during the course. The groups are explained that they will work on a common building and they will be assigned at least one specific architectural unit to constructively design the intervention.

D. Organization

At the systemic level, students carry out the activities collectively. Within the group, the members choose a coordinator who acts as an interlocutor with the teacher and distributes the tasks. For example: he organizes the measurement units, construction analysis, taking photographs, etc. , in the technical visits to the building; or in the drafting phase, similar to the technical office work: he is responsible for the preparation of the report, building-plans, etc.

Regarding the way of sharing information and communicating, students are asked to use ICTs, preferably Dropbox and Microsoft Teams, being OwnCloud, WinRAR and WhatsApp, also common, among others in the collaborative and cooperative framework promoted by the PBL. From the building site, each team is assigned one or several construction units where they will work in depth in the 2nd and 3rd level of exercises.

E. Works and Projects

The core of course practices constitutes the backbone of the teaching-learning system and are structured in three phases:

- (Ps1) Work and Project I. *Preliminary recognition: documentary analysis and pre-diagnosis.*
- (Ps2) Work and Project II. *Comprehensive knowledge: diagnosis, pathology and diagnostic*.
- (Ps3) Work and Project III. *Performance Project: Intervention Techniques.*

The specific goals, activities (A) and assessment criteria are determined in a statement per block, in line with the subject's Teaching Guide (Table 1). Each work and project involves several initial activities (iA) and oral presentations in the classroom (cP).

Table 1. Project phase activities extract

Work and project I **Previous recognition**	**Work and project II** **Integral knowledge**	**Work and project III** **Performance project**
Documentary research	Constructive units of action	Priority actions
Previous analysis	Architectural survey developed	Preliminary actions
Pre-diagnosis	Diagnostic	Interventions
Initial architectural survey	Pathology and diagnosis	Constructive development
Degree of preservation	Preliminary study and preliminary project	Technical appraisal

F. Start-up activities

Start-up activities are intended to stimulate students to begin the first steps of each of the three stages of execution tasks and are organized as follows:

Work Activities and Project I (initial building/construction knowledge phase):

- *Preliminary location and information search:* based on the property's geographic coordinates provided by the teacher. Location proposed in order to begin research. A first approach to the environment and location features, the urban, historical and socio-economic relationships, etc.
- *Pre-diagnosis Sheet design*: for data collection during a technical visit. The teacher explains the information to be included in the format of the data sheet and provides reference models (Figure 2).

BUILDING	
General information	
Property	Private
Address	Castronuevo de Esgueva, polígono 1, parcela 18
Shape and geometry	Rectangular floor plan, 6 modules
Uses	Agricultural (vineyard operation)
Constructed surface	1.235 m²
Age	300 years old approx.
Cadastral Ref.	47045A001000180000US
Urban planning data	
Land type	Rural land
Land qualification	Agricultural
Degree of protection	Not protected
Location and site	
Surroundings	Agricultural environment
Dist. population center	11 kilometers to UEMC
Access	On VA-140/ Agricultural roads
Plot geometry	Rectangular
Topography	Flat terrain, with a slight slope towards the river
Solar path	Southeast main facade

Figure 2. Sample Pre-diagnosis Sheet, excerpt.

- *First building's visit organization:* Students, together with the teacher, consider arrival day, time and route from the university campus, instruments and technology needed for data collection, safety equipment, the survey tour order as well as the task distribution to each group member by the coordinator.

Students present the results of the start-up activities to their peers in class, serving as feedback in the first part of each phase, an essential stage to lay the foundations for the following processes.

Start-up activities of the Work and Project II (integral knowledge, reflection and decision making stage):

- *Complementary technical visits:* in variable number and frequency according to the information gathering needs of each group, planned by the work team, accompanied by the teacher if necessary (Figure 3).
- *File consultation*: available in archives and official information sources, both electronically and in person.

Figure 3. Technical Visits

• *Architectural survey to scale*: performed with delineation systems, usually digital, from data and sketches taken during technical visits. The list may vary, depending on the object of study but in general terms, it includes location and site plans, environment and topography, floor plans, elevations and sections, materials and construction.

Start-up activities of Work and Project III (action proposal and constructive definition phase):

• *Priority, preliminary and intervention actions:* the analysis and reflection on the conservation degree and the pathological processes of both the parts and the whole will determine the priority actions, the preliminary actions of shoring/propping up and demolition/collapse and the intervention actions on foundations, structure, envelopes, interior partitions, finishes and installations and equipment.

• *Choice of the best available techniques:* the search for systems, techniques, means and auxiliary site equipment. The support in manufacturers' technical data sheets and in good construction practice manuals will be essential to choose the appropriate technology.

• *Construction sheets and Technical Solutions planimetries:* to describe in written and graphic form the characteristics of design, execution and use and maintenance of the systems, techniques, means and auxiliary equipment to be used in the works and interventions (Figure 4).

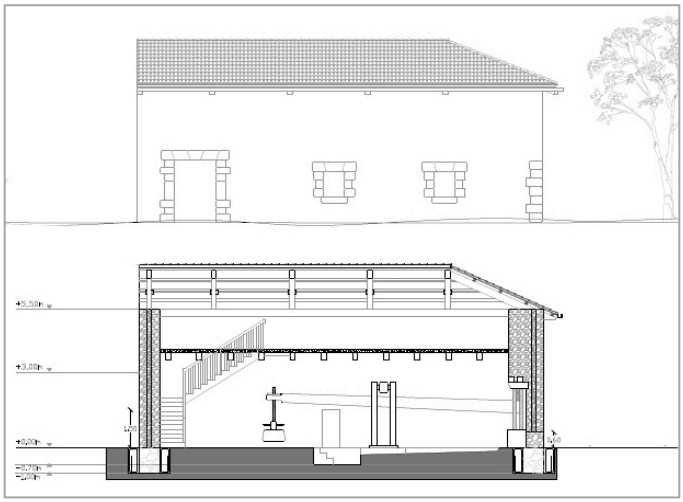

Figura 4. Technical performance plans

G. Oral presentation and group learning

Classroom oral presentations, creating a group learning and reflection environment, organized in two structural levels associated with start-up activities and complete activities.

The first type corresponds mainly to tasks of monitoring and showing progress in the achievement of each Work and Project's start-up activities. The group coordinator, assisted by his/her team, presents the weekly practice results, so that the teacher can guide the phase culmination and the follow-up towards the next milestone. Observation techniques are used to monitor student progress.

The second category deals with the group oral presentation of the result of a work and project, with digital support. Once the activity is delivered, the following week, teams share with their classmates the content considered relevant to the practice carried out, adjusting to the criteria established by the teacher in the instructions. To highlight a few: students spend 10 minutes for projection and explanation, the maximum number of slides will be 10 -including cover and table of contents- elaborated with PowerPoint/Prezi/Canvas or any other presentation configuration tool. The material exposed in the evaluation test must be previously sent in PDF format in the e-Campus platform course. The rubric evaluation criteria, graded from 1 to 4 according to four scales (insufficient, sufficient, good and excellent), include: synthesis capacity and analysis, oral communication, clarity and specificity level, team work and presentation, critical reasoning and customer orientation. Part of the qualification assesses how the group answers the questions on the presented topic, formulated both by the teacher and by the attending students. The evaluation system applied is that for oral tests.

H. Evaluation and Results sharing

The assessment of the work and projects carried out with PBL proposes the common schedule: Continuous assessment-End-semester assessment and July assessment.

As students submit activities for continuous assessment, according to the Teaching guide provided deadlines, the teacher grades the work and carries out a sharing of the results in tutorial or seminar sessions. This feedback mechanism highlights cross-cutting concepts with each team in particular, regarding specific issues, and on a global scale with the whole class to guide the best resolution of the tasks. Students, keeping their group identity, have the chance of re-handing activities, to get a passing or higher grade both in end-semester and July assessments. Achieving a group grade of 5 or higher in each of the three assignments and projects (Ps1, Ps2 and Ps3), as well as in the oral presentations mentioned above, is a necessary condition.

4. Results

Teaching surveys carried out by the University to the degree students at the end of each course semester constitute a first indicator to analyze the PBL methodology impact in historical buildings subjects. The questionnaire is anonymous and organized in five blocks (Teaching Guide, Teacher Performance, Academic Tutorials, Learning Outcomes and General Satisfaction). Of all survey items, those most directly related to PBL methodology evaluation have been selected, distinguishing those associated with Teaching Guide and

Teacher Performance on the one hand (1 to 5) and those related to Academic Tutorials, Learning Outcomes and Overall Satisfaction on the second hand (A to D):

1. Information on the objectives, contents and methodology contained in the teaching guide.

2. Organization and structure of the activities.

3. Resources used to promote learning.

4. Participation encouragement and interest in the planned activities.

5. Learning encouragement by improving knowledge and skills.

A. Tutoring helps me achieve the intended learning outcomes.

B. Learning outcomes understanding.

C. Satisfaction with the achieved learning outcomes.

D. Satisfaction with the training received in the subject.

Figures 5 and 6 show below the students' ratings in the subject of *Rehabilitation, Restoration and Pathology* for those items, measured on a Likert scale from 1 to 5 with the possibility of answering Do not Know/No Answer (DK/NA).

Since data for the current 2020-2021 academic year are not available, the results of the three previous years have been included. Regarding the level of participation in the survey, the record for the 2017-18 and 2019-20 academic years exceeded 75% and it was below 50% in 2018-19.

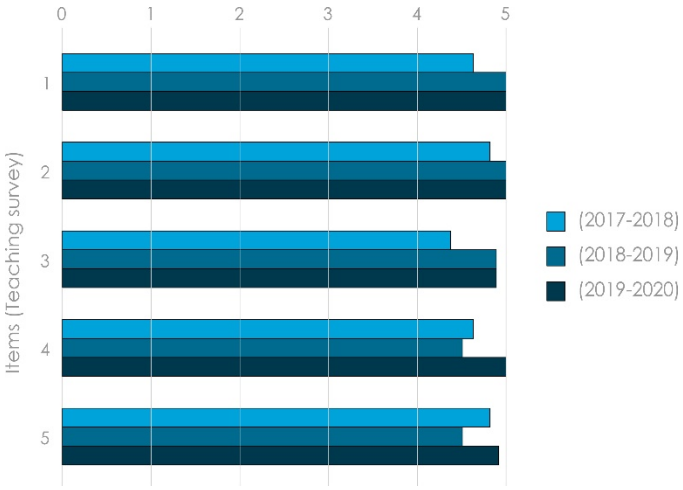

Figure 5. Assessment items 1 to 5.

Although scores are positive, we observed that, as the methodology has been fine-tuned to the students' learning progress after the first year's experience, the student satisfaction degree has increased, especially in didactic resources used in teaching (item 3). This tendency is usually the norm when incorporating a new pedagogical strategy of this type (Sánchez, 2013 and Toledo, 2018).

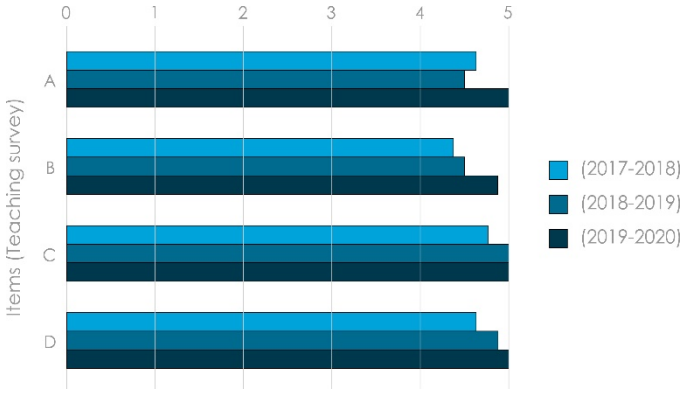

Figure 6. Assessment items A to D.

The evolution continues the same in the aspects surveyed on the teacher's tutorial attention (linked to phase *G. Oral presentation and group learning*), learning outcomes and overall satisfaction (associated to stage *H. Assessment and Results*). The slight decrease shown in year 2018-19 for items 4, 5 and A, seems to be due to the fact that there were three student groups, instead of two, distributing the work more, so that the activities involvement level, learning promotion and attention in teacher's tutorials, were perceived as lower by students. Considering academic performance and results, the difference in the number of team members, is also related to oral tests performance, assignments and projects by increasing the demand for functions coordination and management cooperation, requiring greater leadership and organizational skills from the group leader. Although it is true that 3rd year students should know how to work in teams, this numerical difference, subtle at first, favors students' diversified commitment, affecting the total group involvement. The fact of having to fulfill the final objective as a whole causes some students to bear a greater burden in experiences and tasks, so other classmates benefit from the situation by delegating to others. Thus, they internalize to a lesser degree the value of the methodology for their learning and, although they find it a motivating challenge, they become less involved.

Regarding traditional methods focused on project-based learning without leaving the classroom, experience proves difficult to immerse the student in the problematic situations solved while students experience hardship in acknowledging the work context proposed by the teacher. In this sense, the technique of architecture designed to conserve, reconstruct or complete heritage assets is better designed when learning from the language directly produced by the building is possible, as well as knowing firsthand the actual state of found vestiges.

5. Conclusions

In light of the established skills framework, PBL active methodology is a valid pedagogical strategy that offers favorable academic results in continuous and regular assessment in subjects whose practical purposes require the elaboration of related or chained works on a common topic. It also increases student satisfaction and personal development. The application of experiences and tasks based on a real project challenge, as proposed in the subject of *Rehabilitation, Restoration and Pathology*, which offers an environment where students can interact with the object (existing building/construction) and their peers from a professional-

oriented approach, stimulates the student. It also provides him/her an experiential learning difficult to achieve with training methods based on theoretical cases simulating real-life contexts.

The system structured from three phases of work and projects (activities), driven by the continuous exercise of the students, planned weekly through practice parts (start-up activities) contributes to encourage the permanent connection of the students group with the course. In addition, it facilitates the progressive achievement of a final milestone (partial delivery) of the course tasks. A precise sequential organization in chained stages, based on models taken from the work environment, helps to create a stimulating learning situation where the teacher can provide direct and easy-to-understand explanations. The type and size of the building chosen as a work-base are also important factors when assigning the teams' areas of action so that they all operate in the same pedagogical environment.

Unlike didactic formulas designed for imaginary spaces, direct contact with architecture, allows us to touch the built material element, which is a notable innovation because in addition to carrying out the above mentioned activities, it supports education as an instrument of awareness in heritage protection and conservation. This intensifies its significance, enhancement and social responsibility. One of the strategies promoted by international, European and national organizations dedicated to safeguarding ancient architectures and sites is: educate to preserve, in order to enhance the universality of this legacy in the collective memory.

Given the small number of students enrolled in the Degree in Technical Architecture in past years, class organization in pairs, when compared to larger combinations, has favored the involvement and responsiveness in the performance of a more integrated teamwork, reducing absenteeism or problems usually arising due to lack of involvement. It definitely strengthened the results both individually and in the classroom as a whole. For example, sharing assignments in class stimulates healthy academic competitiveness and feeds back the spirit of improvement and continuous learning, ultimately favoring the level of activity deliveries and oral presentations.

In conclusion, the structural phases designed in the PBL method applied to the field of rehabilitation, restoration and pathology are suitable for subjects dealing with building projects and intervention in existing buildings and, due to their configuration in an open, evolutionary cycle, they can be systemically modulated according to the pedagogical context and the particular purposes to be achieved.

ACKNOWLEDGMENTS

Special thanks to the historic buildings owners for opening their doors to us. To the students, for their involvement in the course and their active participation in the activities proposed through PBL methodology as explained in this work.

REFERENCES

Ausubel, D. P., Donald Novak, J. y Hanesian, H. (1983). *Psicología Educativa: Un punto de vista cognoscitivo*. Ed. Trillas, México.

González Moreno-Navarro, A. (1999). *La restauración objetiva (Método SCCM de restauración monumental)*. Institut d'Edicions de la Diputació de Barcelona, Barcelona.

Heard Kilpatrick, W. (1929). *The Project Method*. Teachers College. Columbia University, 1-18.

ICOMOS (1965). *Carta internacional sobre la conservación y la restauración de monumentos y sitios (Carta de Venecia 1964).* II Congreso Internacional de Arquitectos y Técnicos de Monumentos Históricos, Venecia.

ICOMOS et al. (2000). *Principios para la conservación y restauración del patrimonio construido (Carta de Cracovia 2000).* Conferencia Internacional sobre Conservación, Cracovia.

Onecha Pérez, A. B. et al. (2018). *Las claves de la rehabilitación y restauración arquitectónica.* Volumen 1: El método sistémico aplicado a la intervención en edificios existentes. Autor-editor, Madrid.

Sánchez, J. M. (2013). *Qué dicen los estudios sobre el Aprendizaje Basado en Proyectos.* Recuperado de: Actualidadpedagogica.com

Toledo, P. y Sánchez, J. M. (2018). *Aprendizaje basado en proyectos: una experiencia universitaria.* Profesorado. Revista de Currículum y Formación de Profesorado, 22(2), 471-491.

Vicent Estruch, J. S. (2006). *Aprendizaje basado en proyectos en la carrera de Ingeniería informática*. JENUI, 339-346.