ACTIVE METHODOLOGIES FOR DEEP LEARNING IN SUSTAINABLE DEVELOPMENT GOALS

Inmaculada Romero[1], Maria Pachés[1], María-Teresa Sebastiá-Frasquet[2], Carmen Hernández-Crespo[1]

[1]Instituto Universitario de Investigación de Ingeniería del Agua y Medio Ambiente. Universitat Politècnica de València, (SPAIN)
[2]Instituto de Investigación para la Gestión Integrada de Zonas Costeras. Universitat Politècnica de València, (SPAIN)

Abstract

The general objective of this project was to improve the quality of student learning, from the point of view of a global objective, sustainable development, and therefore aligned with the SDGs (Sustainable Development Goals). It is intended that students achieve deep learning in this area, favouring the transfer of the knowledge acquired to their future professional and social life. This deep learning promotes the integral development of the student, not only from an academic point of view, but also social and ecological.

Project Based Learning (PBL), as an active learning methodology, is being widely used as a deep learning strategy. In this project, it has been used in several subjects, from different degrees, schools, and campus. The learning strategies have been evaluated by means of a learning evaluation questionnaire (CEVEAPEU) before and after the application of the PBL. In addition, student satisfaction and generic skills (i.e. ethical, environmental and professional responsibility) have been assessed.

The project aims to find a solution a specific real case, such as an environmental or social problem. The results show that PBL has favoured the cooperative work of students and has increased their motivation. The students could select the topics that interest them the most and that they consider important in their professional future. They have worked collaboratively and actively, planning the project, making decisions, implementing it, and evaluating it. The students have “acted” and the teachers have been advisors or guides, thus promoting intrinsic motivation. This active methodology has allowed students to learn in a collaborative and cooperative way, fostering their motivation and achieving deep learning in environmental aspects.

Keywords: Project Based Learning, deep learning, motivational strategies, active methodology, Sustainable Development Goals.

1 INTRODUCTION

The Agenda for Sustainable Development adopted in 2030 by the United Nations has the global objective of favouring people, the planet and its prosperity. It lays out 17 Sustainable Development Goals (SDGs) formulated to eradicate poverty, promote prosperity and well-being, protect the environment and tackle climate change. The 17 SDGs are closely related to economic, social, and environmental sustainability. In this work we focus on SDGs related with the environment (biosphere), transversal concept included in SDGs [1].

In Spain, the government clearly defines Universities as facilitators and key actors to promote sustainable human development, fundamentally due to the responsibility they have in education, in the development of a critical spirit and in the incorporation of the principles and values of sustainable development [2]. Sustainability competencies were incorporated into all university degrees, being "Generic skill 07. Ethical, environmental and professional responsibility" at the Universitat Politècnica de València (UPV).

Students tend to learn based on the tasks that are requested [3]. They can simply memorize and later reproduce (shallow or superficial learning approach), or they can learn in a meaningful way (deep learning approach). It is desirable to develop this second approach by designing of learning activities that pose challenges for students. Thus, evaluating students' learning strategies and approaches can provide a diagnosis to implement pedagogical measures for their improvement [4].

Generally, a superficial learning approach is related to the lack of motivation to learn, which in turn leads to a decrease in motivation. However, a deep learning is related to highly motivated subjects, which in many cases increase their motivation [5]. The deep strategy is usually established based on an intrinsic motivation, oriented to want to know, while in the superficial strategy the motivation is usually external, oriented to pass [6].

To consider that superficial learning should be avoided in students is a mistake. Both approaches are necessary, because if you want to promote deep learning, you must first learn basic and fundamental knowledge that will later be used to understand and reflect on a specific topic in a deep way. In addition, a student does not have to approach his learning in the same way in all subjects, not even in all the topics of each subject. It depends on how they consider the task asked to them. It is considered that the learning approaches of the same student change as they encounter the different types of teaching and tasks that are requested [3, 4, 5]. Thus, students are not superficial learners or deep learners, since they can modify their approach or way of learning depending on the needs of each moment [6, 7]. For this reason, in each discipline, or even in each task, the best way to enhance deep learning must be defined.

It is known that overloading the students with theoretical content and testing them continuously without a clear connection between the topics, and even without feedback, favours students adopting a superficial approach. If we desire to promote deep learning, it must be clearly established the expectations that the student has and what prior-knowledge they have on the subject [8, 9]. The activities proposed should encourage active participation and promote connections between different topics, subjects, and/or disciplines. Sometimes it can even be good to give students opportunities regarding the selection of topics or assessment systems. The importance of providing feedback to students to facilitate its improvement and strengths must be highlighted. This will raise student's interest and motivation in the subject [6]. In fact, it has been seen that the teaching strategy used will guide the learning in a different way and therefore the resulting learning will also differ [4, 5, 10,11].

Project Based Learning (PBL) is being widely used as a deep learning strategy. It is a strategy that increases the motivation of students, since it allows that they themselves select the topics that interest them and will be important in their professional future [12, 13, 14, 15]. Students work actively, plan the project, work collaboratively, make decisions, implement it, and evaluate it. One of its main characteristics is that it is action-oriented. The teacher acts as an advisor or guide, it is a tool that focuses on the student, promoting intrinsic motivation [16]. In addition, it stimulates collaborative and cooperative learning. Generally, many of the projects proposed are conceived as the search for a solution to a specific case of the real world, such as an environmental or social problem. The objective is to help them solve complex problems that do not have simple solutions.

Our students show little disposition and are often poorly motivated from an environmental point of view. They are students of Bachelor in Public Works Engineering, Master in Planning and Management in Civil Engineering and Master's Degree in Civil Engineering, with a technical and engineering focus. In addition, they take very few environmental framework subjects, so it is usually quite difficult for them to achieve deep learning. It has been found, over the years, that these students, when taking these subjects related to the environment, only acquire superficial and highly fragmented learning. This is partly due to the low transversality of these contents throughout the courses and to the learning methodologies used. For example, teamwork often ends up being a sum of individual jobs. To all this, we must add to their lack of awareness on the environmental impact that their skills as future engineers have on the environment. Thus, the objective is to incorporate significantly environmental values in students and get them to understand that they influence their environment.

The aim is to improve the quality of student learning, from the point of view of a global objective, sustainable development, that are aligned with the SDGs. It is intended that students achieve deep learning in this area, favouring the transfer of the knowledge acquired in the different subjects to their future professional and social life. This learning will favour the integral development of the student, not only from the academic point of view, but also social and environmental. In addition, it is expected to achieve greater student motivation and promote cooperative work among students. Therefore, the following specific objectives are proposed:

- To implement the PBL in the different subjects
- To incorporate significantly environmental values in students
- To determine if students have been able to solve complex tasks efficiently
- To assess whether collaborative and cooperative learning has been achieved in students

- To show if deep learning has been achieved in students
- To assess whether there has been greater interest and motivation of the student in the subjects

2 METHODOLOGY

In this research, we have implemented the PBL methodology in six subjects, where the students are beforehand reluctant to consider that their future engineering works could affect the environment. The sample matches with the total population of students attending the subjects, 108 students. The applied methodology in the six subjects is PBL. A real problem is proposed to a group of students, for whose solution involve work collaboratively on a project that they must design, following initial guidelines set by the professor, and where each student has an individualized role with objectives to be achieved. Even though the teacher continuously monitors the status of the project, students work with complete autonomy. For this, the steps to follow in each subject were: definition of the starting point or main theme; collaborative team formation; definition of the challenge or product to be developed; organization and planning (assignment of roles and definition of tasks and times); search and collection of information; analysis and synthesis; project production; presentation of the project to other colleagues.

The evaluation of the students' learning strategies is carried out through the Evaluation Questionnaire of the Learning Strategies of University Students (CEVEAPEU) [17], which has been used in various studies. This questionnaire was validated in a satisfactory way [18], evaluating the factor validity, the reliability, and the evidence of the validity of the questionnaire. The CEVEAPEU takes into account the cognitive and meta-cognitive aspects related to learning strategies, as well as motivational, affective and contextual factors [17]. It is a good instrument, consisting of two scales. On the one hand, affective, supportive and control strategies, and on the other hand the strategies related to information processing. It has six subscales (motivational, affective, metacognitive, context control and other strategies, information search and selection, and information processing and use) and twenty-five strategies. It consists of 88 items and is organized into two scales, six subscales, and twenty-five strategies. It is designed with the format of a Likert-type scale, with 5 response options, where (1) indicated Strongly Disagree, (2) Disagree, (3) Undecided, (4) Agree and (5) Strongly Agree Agreement. Its global reliability is $\alpha = 0,897$.

Scale I corresponds to the strategies related to the affect, support and control (or self-management) and is divided into 4 subscales of strategies:

- Motivational strategies (Motiv-Str) that include Intrinsic Motivation (Intrin-Mot), Extrinsic Motivation (Extrin-Mot), Value of the Task (Val-Task), Internal Attributions (Int-Attrib), External Attributions (Ext-Attrib), Self-efficacy and expectations (Self-Expect) and Conception of the intelligence as modifiable (Intellig-Mod).
- Affective components (Affect-Comp), which include Physical and emotional state (Phys-emo-St) and Anxiety (Anxiety).
- Metacognitive strategies (Metacog-Str), which include Knowledge of objectives and evaluation criteria (Know-Obj), Planning (Planning), Self-evaluation (Self-eval) and Control and Self-regulation (Cont-Self reg)
- Strategies of Context Control, Social Interaction, and Resource Management (Control-Str), including Context Control (Cont-Control) and Social interaction and peer learning skills (Soc-interac)

Scale II corresponds to the strategies related to information processing, and is divided into 2 subscales of strategies:

- Strategies of searching and information selection (Search-Str), which includes Knowledge of sources and information search (Know-info) and Selection of information (Selec-info)
- Strategies of processing and information use (Info-Str), which includes Acquisition of information (Acquis-info), Development of information (Develop-info), Organization of information (Organ-info), Personalization and creativity, critical thinking (Perso-think), Storage, memorization, use of mnemonic resources (Mnem-stor), Storage, simple repetition (Simple-stor), Transference, use of information (Transfe-info), Resource management for using acquired information (Resour-mang)

The methodological scheme that was followed was:

- At the beginning of the course, the students answered the CEVEAPEU questionnaire (pre-test). For this pre-test, students were asked to answer the questionnaire in situ, on the first day of class and in person, thinking about their way of facing general learning in the subjects and subjects already taken in the degree.
- The PBL was applied throughout the course.
- After the course, on the last day of class the students answered the CEVEAPEU questionnaire (post- test) in person again. In this case, they were asked to answer the questionnaire thinking about their way of facing learning in a specific subject.
- The results obtained were analyzed by qualitative and quantitative analysis using the statistical package STATGRAPHICS XVII CENTURION.

3 RESULTS

After compiling the questionnaires, pre-test and post-test, the normality of the variables was analysed using the Kolmogorov-Smirnov (KS) test to determine which items could be analysed with parametric tests. All items showed a normal distribution, for which they were subjected to an analysis of variance (ANOVA) using STATGRAPHICS XVII CENTURION, comparing the scores obtained in the pre-test with those of the post-test. In addition, the effect size was estimated using Cohen's d, one of the most widely used measures [19]. It is generally accepted that if d < 0,20 the size of the effect is small, if d is about 0,5 is moderate, and above 0,8 is large [20]. Some authors indicate that if d > 1,30 the effect size is very large [21]. It also calculates η^2, indicating little effect if around 0,01, around 0,06 indicate average effect and if greater than 0,14 is already a large effect.

Figures 1, 2 and 3 show the differences between the means of the different variables in the pre-test and in the post-test. It is observed that for all variables, the means are higher in the post-test.

Statistically significant differences of the pre-test to post-test were found in the Global average score of the questionnaire, with improved post-test [F(1, 212) = 12,35, p-value < 0,001, Cohen's d = 0,88, η^2= 0,27], with a large effect size.

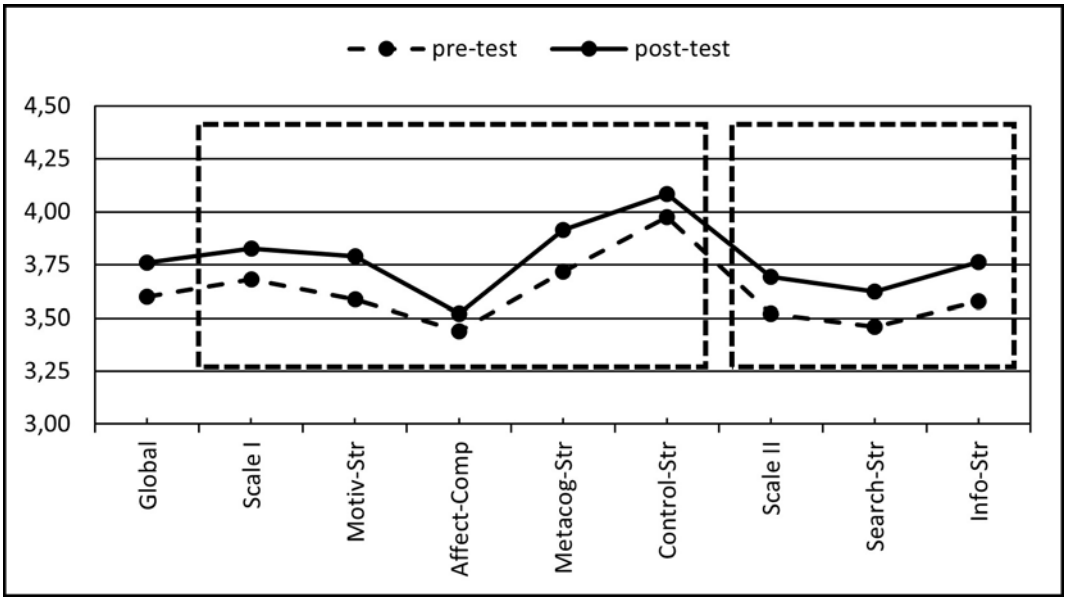

Figure 1. Global Score Means, Scales and Subscales in pre-test and post-test.

Statistically significant differences were also found from pre-test to post-test in the first scale of strategies affective, supportive and control [F (1, 212) = 10,50, p-value < 0,001, Cohen's d =0,97, η^2= 0,21], with a large effect size, and improving the scores in the post-test. These strategies are divided into 4 subscales, which, although they are not directed to the processing of materials, are necessary for quality learning. They are the strategies that start the process, help to maintain cognitive effort,

mobilize, and control the affective part, help to manage the context, and allow the planning, evaluation and control of the learning activity itself [22].

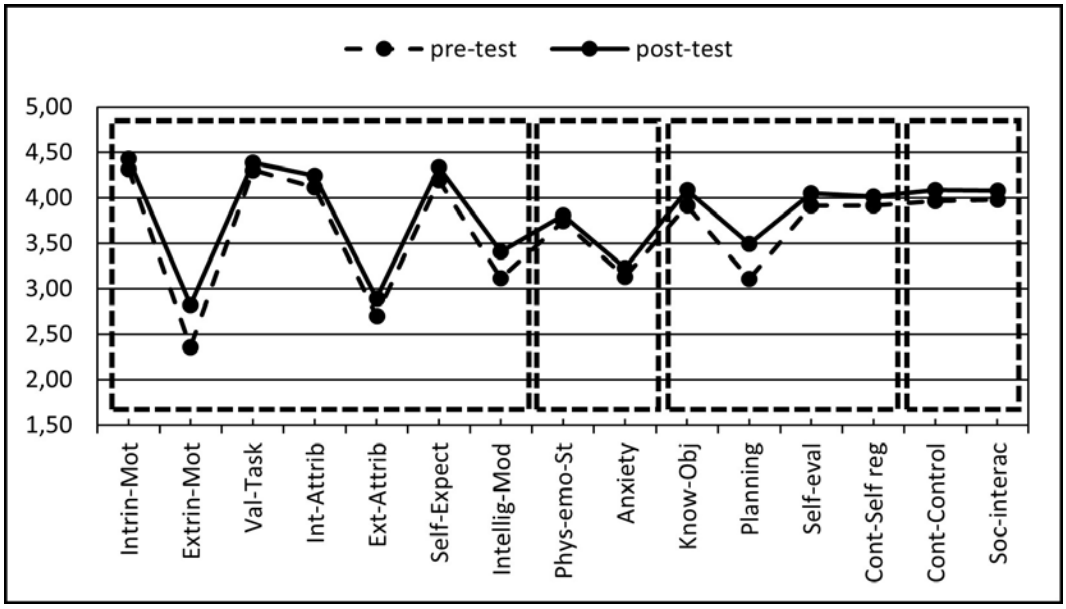

Figure. 2. Means of Scale I Strategies in pre-test and post-test.

The motivational strategies (Motiv-Str) oversee exploring the type of motivation to learn (intrinsic - extrinsic) of the student, intrinsic motivation, extrinsic motivation, external attributions, self-efficacy and expectations, and the conception of intelligence as modifiable. They have higher valuations in the post-test.

The strategies included in the affective components, physical status and emotional and anxiety (Affect-Comp), exploring the physical and mental state of the student, do not showed significant differences, although both higher ratings were obtained in the post-test.

Within the Metacognitive Strategies (Metacog-Str), which explore the strengths and weaknesses of the university student in the face of learning, Planning and Control show statistically significant differences, with higher evaluations in the post-test and medium or large effect sizes. The Knowledge of objectives and evaluation criteria and Self - Assessment do not shown significant differences, but they get higher valuation in the post-test.

Neither of the two control strategies context and Skills social interaction and learning with peers (Control-Str), examining the conditions of study and analyse the work done with others to improve learning, showed significant differences.

The differences were also significant in the second scale, which corresponds to the strategies related to information processing, aimed at the acquisition, elaboration, organization and storage of information [$F(1, 212) = 9{,}88$, p-value < 0,001, Cohen's $d = 0{,}81$, $\eta^2 = 0{,}23$], with an effect value also great effect, and improving the scores post-test.

In the strategies related to the search and selection of information (Search-Str), which explore daily actions to get closer to the information to be learned, and the mechanisms to discriminate what is important from what is not important, both the Selection of information and the Knowledge of sources and finding information showed statistically significant differences with higher valuations in the post-test.

Among the Information Processing and Use Strategies (Info-Str), which explore the actions that the student performs to acquire, encode and organize information, the memorization mechanisms and the ability to transfer and use the information learned, 5 of they showed statistically significant differences. All of them have higher valuations in the post-test.

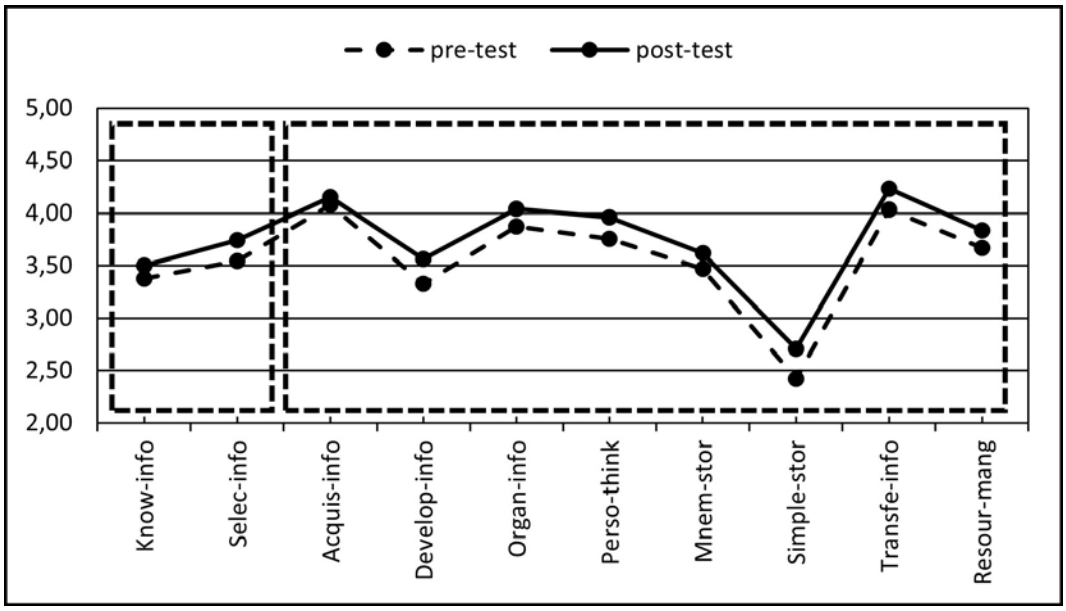

Figure 3. Means of the Scale II Strategies in pre-test and post-test.

These results make it clear that the methodology used (PBL) significantly improves students' learning strategies, fundamentally in motivational strategies, in metacognitive strategies, in information search and selection, and in processing and use of information. However, there are two strategies that, despite improving, do not do so significantly. They are those related to the affective components and the control of the context.

4 CONCLUSIONS

The results of our study show that with the methodology applied, Project-Based Learning, students exercise more and better learning strategies.

The strategies that improve after the application of Project-Based Learning are motivational strategies (fundamentally extrinsic motivation and the conception of intelligence as modifiable), metacognitive strategies (especially planning), information search strategies (fundamentally the selection of information) and the strategies of processing and use of the information (fundamentally the elaboration). Other strategies that enhance are those corresponding to the affective components (physical and emotional state and anxiety) and the strategies of context control, social interaction and resource management.

The results obtained are quite relevant, because the use of active methodologies focused on learning, greatly develops learning strategies. Motivational strategies are the most improve assuring the success of the methodology. Metacognitive strategies are also greatly increased, which is highly related to the work required of students, who need this type of skills. In the same way, all strategies related to information processing, which are essential to carry out learning successfully, also develop.

The use of this methodology as a pedagogical tool has made students learn better, both individually and in groups. This methodology has required an active, constant and cooperative participation of the students, who have assumed more responsibility in the development of their work and have approached the reality of their professional future.

ACKNOWLEDGEMENTS

The project of innovation and educational improvement in which this communication is framed has received financial support from the Institute of Education Sciences (ICE) of the Universitat Politècnica de València (UPV) Proyecto de Innovación y Mejora Educativa (PIME/19-20/174), “Objetivo Agenda 2030 y UPV 2020: Aprendizaje ambiental profundo en la UPV”.

REFERENCES

[1] J. Rockström, and P. Sukhdev, *Sustainable development goals. How food connects all the SDGs*. Stockholm Resilience Centre. Stockholm University, 2016. Accessed 29 May 2019. Retrieved from https://www.stockholmresilience.org/

[2] Ministerio de Asuntos Exteriores, Union Europea y Cooperacion, Secretaria de Estado de Cooperacion Internacional y para Iberoamerica y El Caribe, Direccion General de Politicas de Desarrollo Sostenible. (2018). *Plan de Acción para la Implementación de la Agenda 2030. Hacia una Estrategia Española de Desarrollo Sostenible* NIPO (en línea): 108-19-003-7, 2018. Accessed 29 May 2019. Retrieved from http://transparencia.gob.es

[3] N. Entwistle, *Teaching for Understanding at University: Deep Approaches and Distinctive Ways of Thinking*. Hampshire & New York: Palgrave Macmillan, 2009.

[4] C. Fernandez, and J.L. Arquero, "Evaluación de innovaciones y enfoques de aprendizaje. Presentación preliminar de un instrumento de medida. Innovations assessment and approaches to learning. Preliminar presentation of a questionnaire", *IV Jornadas de Innovación e Investigación Docente*. Sevilla: Edicion Digital Atres. 214-225, 2011.

[5] A. Diaz-Mujica, and M.V Perez-Villalobos, "Autoeficacia, enfoque de aprendizaje profundo y estrategias de aprendizaje", *International Journal of Developmental and Educational Psychology*, INFAD Revista de Psicología, vol. 2, no. 1, pp. 341-346, 2013.

[6] E. Fasce, "Aprendizaje profundo y superficial, Tendencias y perspectivas", *Rev. Educ. Cienc. Salud*, vol. 4, no. 1, pp. 7-8, 2007.

[7] M. Lopez-Aguado, and A.I. Lopez-Alonso, "Los enfoques de aprendizaje. Revisión conceptual y de investigación //Learning Approaches: Theoretical and Research Review", *Revista Colombiana de Educación*, vol. 64, pp. 131-153, 2013.

[8] J.B. Biggs, and C. Tang, *Teaching for Quality Learning at University*, 3rd edit. Glasgow: Open University Press., 2007.

[9] P. Ramsden, *Learning to teach in Higher Education*. Nueva York: Routledge, 2003.

[10] C. Antonelli, "¿Cómo incentivar el aprendizaje profundo?", *XXV Jornadas de Reflexión Académica en Diseño y Comunicación*, vol. 30, pp. 133-135, 2017.

[11] M. Lopez-Aguado, and L. Gutierrez-Provecho, "Modelo explicativo del efecto de los enfoques de aprendizaje sobre el rendimiento y el papel modulador de la dedicación temporal", *Revista de Investigación Educativa*, vol. 32, no. 2, pp. 447-462, 2014. doi: 10.6018/rie.32.2.164761

[12] A. Castro, G. Lopez, A.L. Padilla, L. Melendez, and A.B. Escobedo, "La investigación de un proyecto usado como estrategia para valorar el impacto ambiental por alumnos de química", *Revista Electrónica sobre Cuerpos Académicos y Grupos de Investigación*, vol. 5, no. 10, pp. 1-14, 2018.

[13] M. Maldonado, "Aprendizaje basado en proyectos colaborativos. Una experiencia en educación superior", *Laurus*, vol. 14, no. 28, pp. 158-180, 2008.

[14] E. Rodriguez-Sandoval, E.M. Vargas-Solano, and J. Luna-Cortes, "Evaluación de la estrategia aprendizaje basado en proyectos", *Educación y Educadores*, vol. 13, no. 1, pp. 13-25, 2010.

[15] L.G. Katz, and S.C. Chard, *Engaging children's minds: The Project approach*. Norwood, NJ: Ablex, 1989.

[16] J.A. Marti, M. Heydrich, M. Rojas and A. Hernandez, "Aprendizaje basado en proyectos: una experiencia de innovación docente", *Revista Universidad EAFIT*, vol. 46, no. 158, pp. 11-21, 2009.

[17] B. Gargallo, J.M. Suarez-Rodriguez, and C. Perez, "El cuestionario CEVEAPEU. Un instrumento para la evaluación de las estrategias de aprendizaje de los estudiantes universitarios", *Relieve*, vol. 15, no. 2, pp. 1-31, 2009.

[18] V. Bustos, A. Oliver, L. Galiana, and P. Sancho, "Propiedades psicométricas del CEVEAPEU: Validación en población peruana", *Educación XX1*, vol. 20, no. 1, pp. 299-318, 2017.

[19] P. Morales, "El tamaño del efecto (effect size): análisis complementarios al contraste de medias", 2012. Accessed 14 July 2019. Retrieved from http://web.upcomillas.es/personal/peter/investigacion/TamañoDelEfecto.pdf

[20] J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*. 2nd. edit., Hillsdale, N.J.: Lawrence Erlbaum Associates, 1988.

[21] J.A. Rosenthal, "Qualitative descriptors of strength of association and effect size", *Journal of Social Service Research*, vol. 21, no. 4, pp. 37-59, 1996.

[22] B. Gargallo, I. Morera, and E. Garcia, "Metodología innovadora en la universidad. Sus efectos sobre los procesos de aprendizaje de los estudiantes universitarios", *Anales de psicología*, vol. 31, no. 3, pp. 901-915, 2015.