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Article

The display to build knowledge with projects

El monitor para construir conocimiento con proyectos

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Abstract

The traditional teaching method in higher education in Colombia focuses on memorizing processes and theories, taking notes and repeating them and paying attention to the permanent protagonist of the classroom, who is the professor. In this way, the student is distanced from the construction of knowledge and favors student desertion and academic mortality, which prevents the development of key competencies to develop in the social and work environment. This research approached a methodology of knowledge construction outside traditional stereotypes, based on project-based

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learning applied in Civil Engineering, in several universities: Corporación Universitaria Minuto de Dios-UNIMINUTO, Juan de Castellanos and Universidad Santo Tomás de Tunja, years 2012 to 2020, in the academic spaces Introduction to Engineering and Research Methodology. It was done in different semesters, with the guidance of the principal investigator and the work of nine monitors and the collaboration of about two hundred and fifty students. Surveys, interviews, observation grids and field diaries were applied to students with a selective sample.
Keywords: Active Learning, Dropout, Higher Education, Civil Engineering, Monitor.

Resumen

El método tradicional de enseñanza en la educación superior en Colombia se centra en memorizar procesos y teorías, tomar apuntes y repetirlos y poner atención al protagonista permanente del salón que es el profesor. Así se aparta al estudiante de la construcción del conocimiento y favorece la deserción estudiantil y la mortalidad académica, lo que impide el desarrollo de competencias claves para desenvolverse en el ámbito social y laboral. Esta investigación abordó una metodología de construcción de conocimiento fuera de estereotipos tradicionales, a partir del aprendizaje basado en proyectos aplicado en Ingeniería Civil, en varias universidades: Corporación Universitaria Minuto de Dios-UNIMINUTO, Juan de Castellanos y Universidad Santo Tomás de Tunja, años 2012 al 2020, en los espacios académicos Introducción a la Ingeniería y Metodología de Investigación. Se hizo en diferentes semestres, con la orientación del investigador principal y el trabajo de nueve monitores y la colaboración de cerca de doscientos cincuenta estudiantes.
Palabras clave: Aprendizaje Activo, Deserción escolar, Enseñanza superior, Ingeniería civil, Monitor

Introduction

Higher education continues under the academicist orientation of its teachers, who turn the acquisition of knowledge into a routine that privileges note-taking, memorization and an evaluation that is almost always an exam (Hadgraft and Kolmos, 2020). According to Perico-Granados, Dávila-Bonilla et al., (2020) the importance of fostering expertise, as a continuous relationship between theory and practice that helps the construction of professional knowledge, to mention only one, is often forgotten. Thus, the possibility of cementing about thirty different competencies that can be promoted with the project method is wasted. However, in higher education

students are faced with doing tasks and assignments that may become obsolete in less than a decade.

Pozuelos et al. (2021) state that it is necessary to overcome the classical procedures used for the memoristic and mechanical transmission of knowledge. It is necessary to apply strategies that allow articulating the contents, analyzing them, understanding them and thus constructing knowledge. For Rodríguez-Mesa et al., (2017) the active participation of students in the construction of knowledge is evidenced by the fact that with words they forget, with figures they remember, if they participate they can understand and if the teacher pushes them the students act.

In the third decade of the 21st century, engineering education needs to focus learning on students and really prepare them to face the future (Rodríguez-Mesa et al, 2017). In this regard, reality demands that students have skills and competencies to face the challenges of the fourth industrial revolution, which is not compatible with traditional curricula that revolve around the teacher and do not consider social and professional needs.

Regarding the poor implementation of practical processes in higher education, the Association of Civil Engineering Faculties of Colombia, ACOFI (2010) reports that, for the construction of knowledge, this education does not take into account the importance demanded by the needs of today's society, so that learning often lacks leadership, interdisciplinarity and teamwork. In this regard, the challenge remains for academics to establish methods to build appropriate knowledge.

In accordance with the above, it is considered necessary that a civil engineer begins to develop work skills during his career, such as the ability to identify and solve the problems that today's world demands, as well as the development of personal skills that allow effective communication, promote ethical behavior, development of autonomy for decision making and socio-environmental responsibility increasingly important considering the problems facing the world today (ACOFI, 2010).

On the other hand, in 2013, Colombia had a dropout rate of 44.9% in university education programs. In that year, in the first semester only the highest dropout rate was recorded in technical and professional education with approximately 34%. In the field of engineering, architecture, urban planning and related fields, in Colombia a dropout rate of about 44% was found, during 2015.

Departments such as Boyacá have records above that with a rate above 45%, in the same year. Then, it is essential to use new pedagogies and new didactics that allow the students to be enthusiastic in order to decrease these indicators, such as the project method (Guerra et al., 2017). These aspects urge the search for strategies that allow students to play a leading role for greater motivation and interest in professional training.

In the cases studied, the first four semesters of the civil engineering programs are mainly taught basic science subjects, which focus on theories and methods. There is little application to the professional field for which they are being trained and the didactics that are worked on, mostly lack motivation for autonomous learning (Perico-Granados, Umba et al, 2020). In the same way, few learning environments are elaborated, with a low number of activities, different from those of the classroom, that allow the student to approach the field of civil engineering and that help him/her to propitiate the development of communicative skills. Students with a good academic performance are observed, but at the same time it is not easy for them to speak in public (Perico-Granados, Dávila-Bonilla, et al., 2020).

It was decided to apply the project method in the research to promote the construction of the competencies of the engineering profession and in parallel to cement the human competencies that are very useful to engineers during their personal life and professional performance. The work focused on the contributions that the monitors can generate in the different processes, as collaborators of the teacher in the field work and in the laboratories. Students, monitors, laboratorians, teachers and the main researcher were involved in a team work with defined purposes to optimize the construction of knowledge.

Satisfactory results were found in the implementation of this methodology, which were recognized by students, monitors and teachers, since they are processes that allow building knowledge and forging professional and personal competencies. Among these are autonomy, teamwork, decision making and respect for what is different and labor competencies such as the recognition and good use of laboratory equipment and tools, with the appropriate use of the language of engineering and especially with the development of communication skills.

Materials and methods

The research was carried out in three universities: Corporación Universitaria Minuto de Dios-UNIMINUTO, Fundación Universitaria Juan de Castellanos and Universidad Santo Tomás de Tunja, in the Civil Engineering programs. Students were involved in projects of the profession and in practices of the environment, aspects that sometimes ask them to face problems of different kinds, including ethical ones, related to social needs. Then, they must learn to act, based on reflection on changing situations with a certain degree of uncertainty (Hadgraft and Kolmos, 2020).

It was decided to work with project-based learning, which promotes teamwork, among other characteristics, and students change the traditional actions summarized in listening and reading about generic concepts. They, with the method apply theory to solve real-life problems, allowing these to establish the relationship between the work they develop and the professional world beyond the academic (Gonçalves, 2014), (Perico-Granados et al., 2019).

Within the educational classification, project-based learning is immersed in active learning, with a great protagonism of the student, who has to solve real and genuine problems. Teachers and monitors always acted as guides and avoided active participation. They only did so when necessary, in moments of feedback or when students were getting off track. In this regard, this strategy is based on democracy and participation, it offers students independence, autonomy and responsibility in the construction of knowledge, since they make decisions about what, how, when and why to learn (Rodríguez-Mesa et al., 2017).

In the same sense, the teacher changes his role in the construction of knowledge, since he does not act as a transmitter of concepts, but becomes the guide, who guides the student to find the solution to the problem that prompted the research, in which he applies the knowledge acquired in the subjects (Reverte, et al., 2007). It is worth mentioning that project-based learning helps to develop skills for good teamwork, to plan the time and the work to be carried out, to know effectively the processes to be executed. It also promotes autonomy to make decisions appropriately throughout the process. Then, projects with these purposes turn out to be more motivating for students, aspects that are usually reflected in their interest in the subjects they study and finally in their academic performance,

elements that prepare them much better for their work performance (Kolmos et al., 2021).

In the same way, the method allows students to approach with their field and laboratory activities to the activities they will encounter in their professional work, for which they are preparing. It significantly increases the motivation for their own training and their commitment to study, since the projects become challenges that awaken the skills and creativity to build real solutions to real problems, acquiring human and professional skills (Perico-Granados et al, 2017), (Kolmos et al., 2021).

In terms of the principles of project-based learning, common approaches can be found, despite the variation in the models that are implemented. On the one hand, there is the approach to learning that is oriented to problems and the student's experience, an aspect that calls for a more thorough analysis to solve it. On the other hand, there is the approach to content, taking into account that interdisciplinary learning is sought, in order to go beyond the traditional limits of the subjects. Finally, the social approach that translates into teamwork and autonomous learning, where there is dialogue and communication, a space in which students learn to share knowledge and organize processes together in the search for solutions (De Graaff, Kolmos and Du, 2017).

The project-based learning method, for this research, was implemented in the construction of knowledge with students in the first semesters of the Civil Engineering programs of the three universities mentioned above. The principal investigator together with the teachers at different times, specified the aspects of the method to work and during the work period there was interaction with the monitors, young researchers, laboratorians and in almost all of them with members of the communities affected by the problems. Thus, the teachers urged the students to form working groups of three people each, to identify a problem in their immediate environment, related to their profession, with the guidance of the teacher.

The problems encountered, studied and analyzed in the projects are related to road geotechnics, building pathologies, deficiencies in drinking water supply, sewage contamination, solid waste disposal, vegetation cover and landslides, among others. The projects were worked on during one semester and in some cases in two, obtaining results expressed in team presentations and good quality written

reports. In this way, decision making and autonomy in the different processes that were carried out during this time were cemented. In this aspect, decision making by the students becomes a requirement to take ownership of the project and thus become more motivated by its development (De- Graaff and Kolmos, 2007).

The method was implemented between 2012 and 2020, during which time nearly one hundred and ninety projects were carried out with students, with the guidance and collaboration of seven teachers from different academic areas, the follow-up of nine monitors and the support of five laboratorians, at different times, in the three educational centers. In one specific case, there was the collaboration of a monitor, who participated in the follow-up of about sixty projects during three years. In this way, evidence could be collected more effectively and the contribution of his participation in the process could be established, based on the fact that he had experience in the development of the method and in several subjects in which the method was implemented. Surveys, interviews, workshops, observation grids and a field diary were applied. The information was triangulated and the results and conclusions presented in this research were obtained.

In all cases, the students were motivated to explore their environment to find engineering problems that they were interested in investigating. In the few cases in which they did not find them, the researcher presented a list of possible problems so that they could take them from there. This covered the various fields of the profession and each group had the autonomy to choose the topic they thought best to develop the project. The projects followed the methodology used in these university centers, from an excellent construction of the problem, state of the art, elaboration of objectives and theoretical framework, to methodology, schedule and budget (Perico-Granados, Caro-Camargo et al., 2015), (Perico-Granados, Garza et al., 2020). Likewise, the execution of the projects was carried out with a variable duration, depending on the case.

In 90% of the projects, students were taken, with the guidance of teachers and the accompaniment of monitors, to take field samples of geotechnical, structural, water, or solid waste. In this way, they had an approach to professional work, which was deepened with laboratory tests and then with the analysis of the results. The teacher guided them and the monitors, in the absence of the teacher, to investigate in the books the concepts to put against the data obtained

and to find by their own means the conclusions that they themselves built. The field work was complemented with visits to construction sites under construction and in a few cases to others already completed.

The monitors always made the students keep in mind the application of the technical standards for the elaboration of the laboratory tests, taken to the soils of the areas studied and to materials such as asphalt and concrete. Among the main ones worked with the students are the Colombian Technical Standard (NTC), the INVIAS (National Roads Institute) and the American Society for Testing Materials (ASTM) standards. The laboratory tests were carried out with the help of laboratorians from the three universities and with the implementation of the experimental work guides. However, the students played a central role in all processes and activities.

The main tests carried out were related to the characterization of materials and the obtaining of their strength properties. Among them, the following stand out: granulometry by sieving, obtaining consistency limits, simple compression, direct shear, concrete compressive strength, design of cold mixes with asphalt emulsion, stability and flow of hot asphalt mix, with the use of Marshall equipment, and granulometric analysis of aggregates extracted from applied asphalt mixes, among others. In this way, the students, with the timely guidance of the monitors, began the construction of the expertise, as the symbiosis of theory and practice.

At the end of the development of the projects, in order to evaluate the impact of the application of the method, with the active participation of the monitor, in the students' training during the process, a survey of ten (10) questions was applied, focused on evaluating the effectiveness of project-based learning. Likewise, the development of personal and professional competences was measured, as well as the students' interest in the professional field, the ease of remembering the knowledge obtained in the process, the decrease of academic desertion, the relevance and effectiveness of the inclusion of monitors and the help provided by the monitors during the progress of the projects, among others (Miranda, 2016).

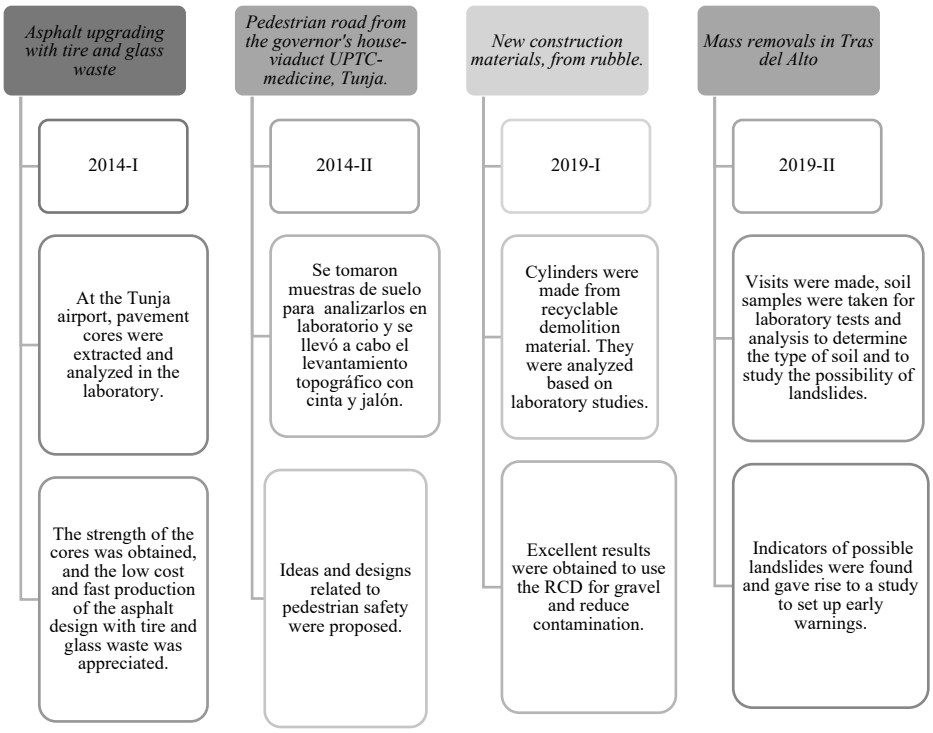
Results

As a result of the application of the method with the collaboration of the monitors, in the three university centers, several positive results

were obtained, but the first three aspects stand out: first, the remarkable relationship established between theory and practice during the construction of knowledge in the various fields of engineering, considered in the development of the projects. These elements created in the students a greater closeness to the language and professional practices. Secondly, the excellent communication and interaction of the students with the monitors, aspects that allowed a better construction of knowledge and facilitated good teamwork. Finally, there was a notable increase in learning for a greater amount of time, as permanent support in the process carried out by the monitors, given their experience and knowledge in the work that was carried out, with the accompaniment during sampling, laboratory tests and field trips.

Project-based learning was implemented specifically in the academic spaces of Introduction to Engineering, Research I, Research II, Research Seminar and Degree Seminar, in several semesters of the curriculum, in the three university centers. Of the one hundred and ninety projects that were worked on, to evaluate the results, 50 projects were selected from the years 2013 to 2019 and one hundred and thirty students participated in them to take information from surveys, interviews, field diary and information grids (Miranda, 2016), (Perico, 2017), (Perico-Granados, Dávila-Bonilla et al, 2020). In this regard, the variety of topics developed in the projects allowed the students to have a broad overview, close to the reality of the civil engineering profession. Figure 1 shows a sample of projects executed during the process of applying the method, with the contributions of the monitors.

Figure 1. Examples of projects developed with the project-based learning method in Civil Engineering.



In all the projects, the monitors were in charge of explaining to the students the use of instruments, tools and equipment to take samples in the field and transfer them appropriately to the laboratories. They also specified the procedures to be followed during the laboratory practices, observing the technical standards to be applied in each activity. They were aware of the distribution of work equipment to avoid accidents and for the proper development of the projects.

About 96% of the students expressed their satisfaction with the use of the method, its usefulness in their professional training and the support they found in the monitors. They emphasized the development of communication skills, especially in public speaking, and gave relevance to the use of terminology in the field of civil engineering. Regarding human competencies, students considered teamwork and personal growth aimed at autonomy training as the most relevant for all processes, such as decision making and respect for the diversity of thoughts. In this regard, engineers require an increasingly demanding profile, with transversal competencies such as teamwork, autonomy, critical thinking, creativity and the ability to take risks and solve problems (Gonçalves, 2014).

Additionally, it was found that around 90% of the students felt a greater motivation and interest in the development of the project, since they were able to choose in group the subject they wanted to address, actively committing themselves to their own learning. Cases were found of students who, in the fourth semester of Civil Engineering, had the intention of dropping out of the program because they did not find answers to their professional field in the subjects they had taken. With the projects, the accompaniment of the monitors and the positive comments during the process, especially their approach to the real work of the profession, they decided to continue with enthusiasm their professional training process.

Another example of the positive effect of this method with the accompaniment of the monitors was found in the decrease of the percentages of academic mortality. In one of the educational centers, the percentage obtained in the subject of Study and Research Workshop in 2008, recorded a mortality of 28%. With the percentage obtained in the subject of Introduction to Engineering in the year 2016 obtained a mortality of 2%. The change is only the name of the subject since it kept the same contents and was directed by the same teacher as in 2008. It should be noted that in 2008, traditional teaching was applied and the student evaluation was carried out with the Icfes proposals and in 2016 the method applied is project-based learning (Perico, 2017). In the information obtained in the instruments used, the students recognized the importance that the guidance and accompaniment of the monitors had during the process, mainly to explain and motivate them throughout each project.

The students emphasized that the knowledge they obtained during the development of the project, they remember more easily, since the learning did not lie in a memorized concept, but in putting theory into practice, so that finally they add to their training experience and not only axioms. According to students, project-based learning revolves around deep learning and critical thinking, in which they can be contextualized on real life, through the theory-practice relationship (Gonçalves, 2014).

The role of the monitor is based on establishing a closer relationship with the student, supporting the teacher in the process, especially in activities such as sample taking, laboratory tests, field work and site visits. Regarding the work done by these actors of knowledge, three fourths of the students consider that they did an excellent job and

supported the teacher in the development of the subjects. In this regard, three out of four students propose that the project method be implemented in more subjects and that the monitors become a help in all of them.

In the three university centers there are different ways of motivating the participation of students to develop the activities of monitors. However, what was found is that in addition to the important contribution to the construction of the students' knowledge, in practice and in theory, they, the monitors, are the ones who benefit most from the process because they continue learning from the experiences and concepts they investigate. They, with patience and concrete and timely explanations, achieved an adequate interaction with the students. They were an important part of the work teams, since the students found in them the help to overcome the difficulties that arose throughout the development of the project. In this way, they guided both the analysis of results and the search for the most appropriate solutions to the problems posed.

The teachers also emphasized the relevance of the work of the monitors, who they consider as actors closer to the students, who help solve problems when faced with new experiences in the construction of knowledge, especially at the beginning of professional training. In addition to the work described above, the monitors develop and update new laboratory testing and sampling guides to improve the processes.

Discussion

During the development of project-based learning in the different academic spaces, the advantages provided by this method in the process of knowledge construction were evidenced, with the contribution of the monitors. In this way, human and professional competencies are developed and it allows to reduce dropout and educational mortality. Students become the main actors, encouraging critical thinking and greater confidence in the application of knowledge. The monitors promote autonomy in decision-making to face the real problems faced by a professional in the course of their work, which leads them to become even more interested in their careers and to take responsibility for their own training.

The method promotes teamwork and leadership skills in students, important skills that are constantly sought after in the recruitment of personnel, since the Civil Engineer must be able to face the risks that may arise in the projects he/she carries out and at the same time take the initiative to seek effective solutions to help solve problems, so active professionals are required, considering the needs and the constant change of today's world.

Students have a better approach to the basic knowledge of the subject, since they do not finish the course only with memorized concepts, but they obtain results as a result of the experience, and the mere fact of relating them to real practices allows them to remember them better, as well as a better handling of the language of the professional career.

The role of the monitors during the process helped the students to have a closer support during the execution of their projects. They clarified concepts and procedures for the practices necessary for the search for solutions. They established knowledge feedback during the implementation of practical and theoretical processes and procedures for learning. They themselves also developed human and work competencies that strengthen their professional training.

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