

PROJECT-BASED LEARNING (ABP) IN THE TEACHING OF MATHEMATICS IN THE CONTEXT OF COMPUTER PROGRAMMING

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Abstract

Mathematics is one of the areas of knowledge where there are greater difficulties for its learning, due to its complexity, and the little usefulness that is perceived of them in real life, which is why pedagogical alternatives have been developed (ABP). The usefulness of this tool in learning mathematics, which is sought by solving real problems through the use of mathematics. In this sense, the use of the PBL was evaluated in a group of 60 students of the Software career of the Polytechnic High School of Chimborazo (ESPOCH), 30 before the use of APB and 30 after its use comparing the changes in the academic performance of the students after the implementation of the PBL, as well as the perception of the students in relation to the interest, value, motivation and utilities of mathematics by solving problems using differential equations, The results found show that the students had a greater achievement when understanding and solving the equations adequately using derivation rules and analyzing and adequately interpret the information, which was related to a greater interest (50.85%), assessment (57.36%), satisfaction 57.62 (%) and utility 66.07%, despite the fact that the use of the PBL achieved a significant increase in grades, even the students state

that they make a great effort to carry out projects in the area of mathematics, which was expressed by more than half of the students approached, the findings found lead to the conclusion that the use of this learning tool translates into a significant improvement in the acquisition of mathematical skills since a greater understanding and importance of the use of the itself, increases the interest and motivation of students for their study.

Keywords: learning, mathematical analysis, derivatives, informatics, programming.

INTRODUCTION

The key to successful professional development in the different academic disciplines, but especially in the area of science and technology is the learning of mathematics, given that in the field of engineering (García, 2013) many of the problems for the design of works (Ramos, 2021), device (Guerrero and de la Torre, 2020), healthanification (Garrido et al., 2022) and performance estimation (Castañeda and Potes, 2019) are based on mathematical equations, but despite the importance of the same, the development of these competences is not achieved in its entirety. by the students of these careers.

A person with competencies for mathematical analysis has a set of knowledge and skills that allow him to identify data, perform basic numerical operations and is able to analyze economic facts, (Ozuna and Díaz, 2019). In this sense, the challenge facing education is to help create a society with knowledge about the use of skills and abilities for numerical calculation such as: medicine (Ortigoza and Lorandi, 2021), agronomy (Pereira and Dos Santos, 2019), industrial engineering (Caligaris et al., 2019), epidemiological (Vidal et al., 2020), seismology (Vitoro, 2022), hydrology (Suarez et al., 2020), etc., however, this information can become useless data if they are not processed correctly and the appropriate processes of data collection, treatment and analysis are not carried out (Barreto, 2012).

One of the greatest difficulties for the learning of mathematics and that would be analyzed in the context of the career of Software, which is one of the disciplines that is part of the academic offer of the Escuela Superior Politécnica de Chimborazo (ESPOCH), is that students manifest difficulty in learning mathematics, due to demotivation (Castro and Miranda, 2019), disinterest (Quiroz and Yogi, 2020) and the little usefulness they perceive from the same (Peña and Camacho, 2020), given this concern, teachers have developed pedagogical alternatives that seek to increase the commitment and disposition of the students before to study this subject and that this in turn manifests itself in a better academic performance, being the project-based learning (PBL)

the strategy selected for this purpose, since the learning process is based on the compression and resolution of real problems.

The educational process under the modality of projects, although it is not new, since as pointed out by Matos et al., (2015), there are several authors who have used classroom projects as a didactic strategy through the use of real situations of daily life and different concepts related to other disciplines, however this teaching strategy has been adapting to the curricular contents and improving its application, checking the active stimulation by the students in the classrooms.

The first proposals for the use of projects as a learning strategy, which was called PBL, emerged at the beginning of the last century and which were formulated by Kilpatrick (López et al., 2015) based on the need for change and innovation, based on the fact that students learn in relation to life from what is valid and whose objective was to use PBL in order to use the innate potential of students, in order to instruct them to be responsible individuals and with a high level of motivation towards the acquisition of knowledge, defining a project as the act performed in a social environment, in the search to carry out an enthusiastic activity with a specific purpose.

Education based on PBL beyond promoting a significant accumulation of concepts, many of them abstract and without practical link, seeks to promote commitment and motivation to students of any level, being the main challenge established during the exchange of knowledge at any educational level. In this order of ideas, several studies have reported a significant amount of research that shows that there are a series of didactic strategies that promote the participation of students in the construction of their cognitive skills, which to some extent replaces those methodologies based on a repetitive learning approach and is based on more complex activities with an interdisciplinary vision unlike traditional approaches.

Project-based methodologies (PBL) is defined as a teaching modality focused on activities and that implies a process of consultation and agreements between the teacher and the students (García and Gomes., 2017), whose purpose is the realization and delivery of a final assignment where the results of the knowledge and skills acquired during the realization of the project are reflected, The projects are based on the acquisition of cognitive elements autonomously and individually.

Considering the above, the objective of this research was the implementation and methodological assessment of a project to optimize the method of teaching mathematical calculation based on projects (PBL), through the promotion of cooperative work, with the aim that students integrate the acquisition of knowledge and the development of their skills through the motivation that implies having an active role in

the analysis of mathematical equations through derivation for the resolution of real problems.

MATERIALS AND METHODS

Contextualization

The research project was carried out at the Faculty of Computer Science and Electronics of the Chimborazo School of Physics, in the Software career, where mathematical calculation is taught or with emphasis on skills for the use and management of derivation rules, which is an Ecuadorian institution of higher education, with headquarters in the city of Riobamba, Ecuador (Figure 1) and since 2012 belongs to the Ecuadorian Network of Universities for Research and Postgraduates.

Figure 1. Location of the Polytechnic School of Chimborazo.



This educational institution was created in Created on April 18, 1969. It began its academic activities on May 2, 1972 with the Schools of Zootecnical Engineering, Nutrition and Dietetics and Mechanical Engineering. It was inaugurated on April 3, 1972. It is accredited by the National Council for Evaluation and Accreditation of Higher Education of Ecuador (CONEA) in 2022, currently this body no longer classifies Ecuadorian universities by categories, which defines it with excellence in higher education, equipment, furniture, educational services, qualified teaching staff, educational requirement, pedagogy, among many other points of study.

It is an Ecuadorian Higher Education Institution that has its origin in the Higher Technological Institute of Chimborazo, created by Law No.69.09, issued by the National Congress, on April 18, 1969, began its academic activities on May 2, 1972. The Polytechnic School of Chimborazo is currently made up of 7 faculties, 2 campuses and has 44 careers.

ESPOCH Educational Model

The educational model of the institution is based on the critical-socio-humanistic approach which arises from the reflection on the institutional practice of existing socio-educational trends and determinations and their implications, which consists of an alternative approach that rescues the institutional identity and responds to the social, cultural, economic, environmental and axiological problems, which promotes the liberation of thought, human action and the integral development of society.

Population and sample

The population includes the 90 Students who study the mathematical calculus signature or, of which 34 were enrolled in the course before the application of the PBL and 56 after the PBL who are located in the academic program of Software of the ESPOCH, from which a sample of 60 students was obtained (30 before the use of APB and 30 in the period after its use) the sample tot to the par to the application of the IMI questionnaire in the evaluated academic periods, divided the study into two phases prior to the use of the PBL strategy and after the application of the same

Participants

The academic year in which the research is carried out are in the subject mathematical calculus or the Software career and is constituted by sixty (60) students, who were assigned a mathematics project for the resolution of real problems using mathematical tools whose Performance and performance was compared with the preconditions for the implementation of this learning strategy .

Variables

The variables evaluated for the comparison of project-based learning (PBL) compared to the exclusive use of face-to-face education through lectures, was evaluated by estimating the degree of satisfaction of its use by studentsof mathematical calculation. , in which the parameters were considered: knowledge, understanding, enjoyment, effort, collaboration and usefulness of the learning process based on the use of multimodal education systems.

Instruments

To assess the degree of satisfaction of the students an applied vezor the model of learning based on projects in the subject gives mathematical calculation. the information was collected through the application of the IMI questionnaire, which is described below

IMI Questionnaire

For the collection of data regarding the motivation and the level of satisfaction with which the students of mathematical calculation, after the use of project-based learning systems, the IMI questionnaire was used, which is an instrument that has been previously validated by numerous studies to motivation, which allows to measure the level of acceptance and motivation of students for the learning of mathematical calculation (Guido, 2017).

For the evaluation, aspects related to knowledge, understanding, enjoyment, effort, collaboration and usefulness were considered, which were evaluated through a scale with 5 levels which are described below: 1. Much, 2. Quite, 3. Something, 4. Poco and 5. Nada, this instrument was applied prior to the implementation of the learning strategy based on multimodal systems and after the delivery and evaluation of the project, and where evaluations 1 and 2, Much and Enough, will be cataloged as positive evaluations.

The questionnaire used to establish the degree of knowledge and motivation prior to the use of the project-based learning tool was applied to students of mathematical calculation is described in Table 1.

Table 1. Questionnaire on motivation prior to the use of project-based learning (PBL) of students of mathematical calculus or software theory

Questionnaire 1	A lot	Pretty much	Something	Little	Nothing
The activity can be interesting					
Project material has been understood					
I feel tension for the activity to be carried out					
The activity has a personal value					
You like to work in a team					
I believe that with this project interpersonal relationships will improve					

Likewise, the questionnaire used to establish the degree of knowledge and motivation was applied after the use of the project-based learning (PBL) tool to students of mathematical calculation described in Table 2.

Table 2. Questionnaire on motivation to assess the use of project-based learning (PBL) of students of mathematical calculus or software

Questionnaire 1	A lot	Pretty much	Something	Little	Nothing
I would describe the project as very interesting					
I felt tense during the execution of the project					
My level of effort was high					
I am satisfied with my performance during the project					
After working on the project I felt competent					
I consider this type of activity useful.					
This activity has contributed to improving the relationship with my group of colleagues					

Source: adapted from Guido (2017)

Resources used

The resources used for the processing of the data of the application of PBL in the teaching of calculus were computer programs for the determination of parameters of descriptive statistics and the Excel program was used for the realization of the pertinent graphs.

Timing

The study was developed during the year 2022 where the project-based learning strategy (PBL) combines the use of the online platform as a support for face-to-face classes, product of the adaptation to the face-to-face modality after the lifting of health restrictions after the pandemic.

Procedure

The project will cover several stages from choice of the topic, formulation of the project, execution of the same, until ending in the delivery of a final product, in power point, where the most relevant aspects of the project are summarized, the analysis of the situation raised and the final reflection, after the presentation of the product the self-evaluation and co-evaluation was carried out in order to introduce corrections and modifications in the progress of the same and establish the final qualification of the project.

Choice of theme

One of the most important stages of the project is the choice of the topic which should be motivating, of current interest and that the application of the methodology of project-based learning for the application of mathematical competences. The derivatives and their application in computer science: critical points, minimum and maximum (efficiency), graphs.

Development of the theme

Once the topic has been selected, students are provided with the basic documentation of what it implies and contemplates the project to be developed, where the questions are posed as an orientation in order to develop the topics to be investigated, establish the background and develop strategies for the achievement of the final objective, which is the understanding of the selected topic: Correct selection of the topic or situation to be addressed, which is the use of rules of derivation, first derivative, second derivative, for the correct analysis of the situation and the obtaining of correct results.

For the realization of the project, groups will be formed according to the compatibilities between the students with a view to promoting cooperation links, these students must analyze the data, use the mathematical tools of derivation included in the current curriculum and deliver a final product in power point with the statistical results using joint graphics, Responses and conclusions.

The groups prior to the realization of the project, must present a work plan that includes project content, objectives, research models, data collection methods, classification, analysis and interpretation of data and presentation of results, it should be noted that students enjoy autonomy in the search, analysis and contrast of the information that is required, where the role of the educator is that of guide and counselor, clarifying doubts, promoting self-evaluation and making corrections where necessary to facilitate the achievement of the final objective, being the only obligation that the data collected come from the official entities in charge of monitoring the pandemic in Ecuador.

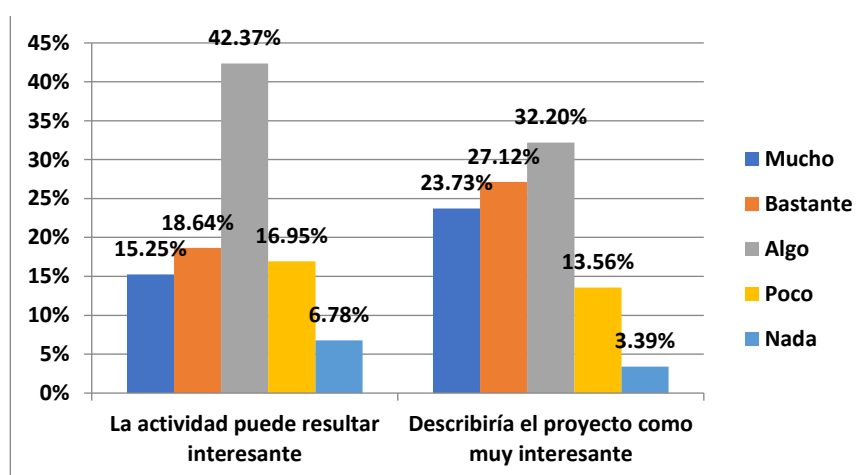
Data analysis

The results corresponding to qualitative parameters generated from the IMI questionnaire to determine the degree of satisfaction were analyzed through descriptive statistics by comparing the average values obtained for each item evaluated in the questionnaire, comparing the percentage of students able to meet the competencies achieved through the use of project-based learning, in the development of mathematical competences comparing this performance with the level of performance and expectation prior to the use of the same.

RESULTS AND DISCUSSION

The results found are satisfactory both from the motivational aspect with the academic performance of the students of mathematical calculation of the Software career, after the implementation of a project-based learning model (PBL) on The first aspect evaluated was related to the motivation of the students for the learning of mathematics, which in Figure 2, shows a positive assessment after the project of 50.85 % compared to the initial assessment of 33.89 % with only a negative assessment of 16.94 %.

Figure 2. Level of interest for the realization of learning project in mathematics in students of the ESPOCH of the Software career.

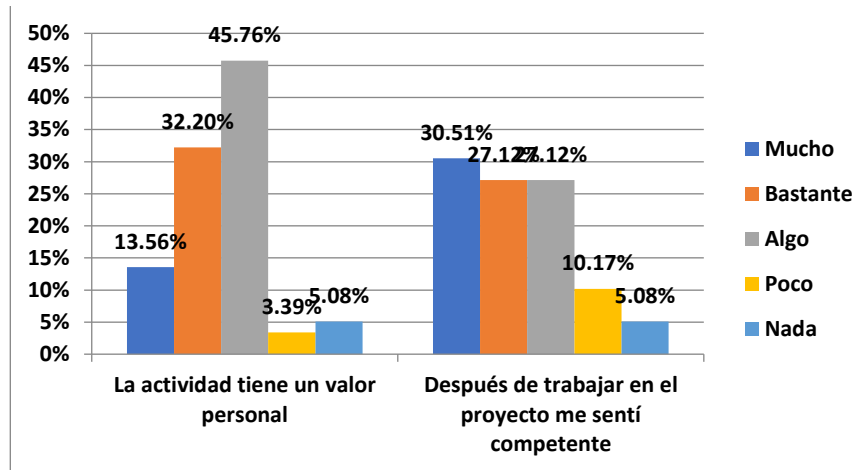


The results coincide with those found by Vera et al (2022), who demonstrated that PBL develops motivation to learn, since allowing the strategies to be effective, due to the stimulation received, facilitating that schoolchildren remain committed, motivated during the realization of activities, strengthening their learning with a lot of autonomy.

In this same order of ideas, Botella and Ramos (2020) highlight the importance of PBL to promote learning, concluding that students were able to systematize the learning project and operationalized giving meaning to the concepts worked thanks to personal motivation and were able to provide efforts, and were autonomous in paying attention, monitor and monitor their progress.

The second aspect considered was the assessment that students have on the use of this mathematical tool for learning mathematics, in this sense the use of PBL had a positive assessment of 57.63 %, which exceeds the initial perception of 45.76 %, with a negative rating of 15.23 % on the use of ABP for learning mathematics (Figure 3).

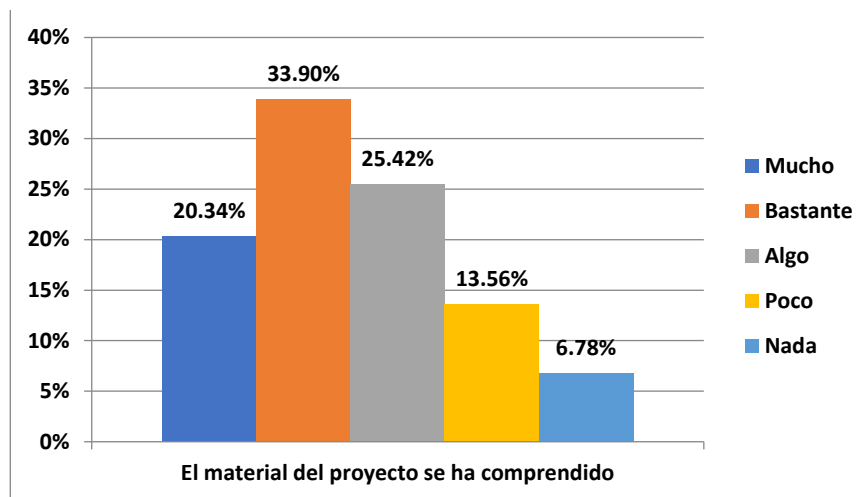
Figure 3. Assessment of the realization of learning projects in mathematics in alumnos of the ESPOCH of the Software career.



Authors such as Jiménez (2019) affirm that for students to positively value the learning of mathematics, the teaching of mathematics must be focused on the generation of skills so that the student develops the ability to solve everyday problems, while strengthening logical and creative thinking, in accordance with this affirmation Leiva (2016) suggests the use of active methodologies such as Project-Based Learning (PBL), a teaching and learning modality that tries to reduce the limitations of traditional methods, promoting situations closer to reality and turning the student into the main actor of the educational process.

An important aspect to ensure that learning through the use of PBL achieves the expected objectives is that the material provided to students is understood, in this sense in figure 4 it is observed 54.24 % of the students approached consider that the didactic material was understandable, However, 19.34 % considered that it did not allow them to understand the problem posed to be solved using mathematical skills.

Figure, 4. Compression of didactic material used for the realization of learning projects in mathematics in students of the ESPOCH of the Software career.

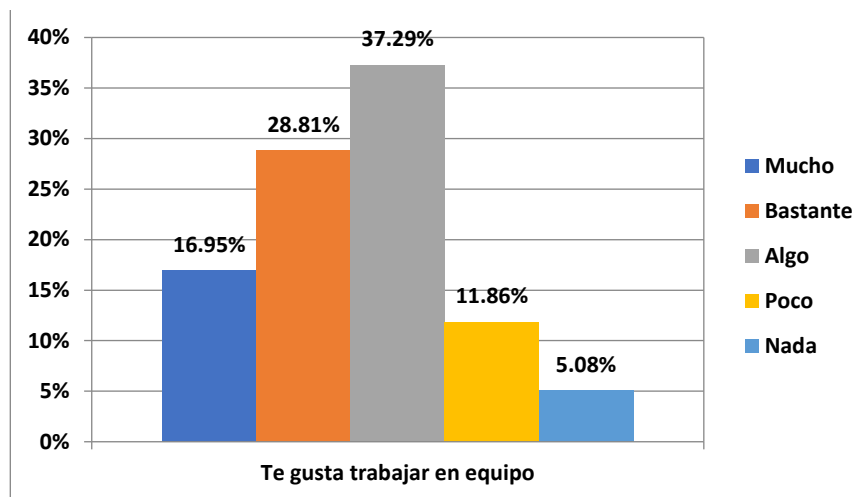


Ensuring that the didactic material is understood is fundamental for the success of the project since authors such as Hernández et al., (2017), highlight that students often present difficulties in the management of concepts and little understanding in topics that are basic to advance systematically in their academic training, if the objectives set with the introduction of new learning methods such as PBL are not achieved, will fail with negative results.

Given this, Torres (2019) affirms that the creation of educational materials is a key aspect of the incidence of new learning strategies, therefore, its preparation for the teaching-learning process constitutes the central axis of any pedagogical strategy due to the numerous didactic possibilities they offer to work not only conceptual contents, but also procedural and attitudinal, contributing to the acquisition of competence.

An important aspect and that results in a valuable competence when performing in the field is the ability to perform work in teams, although it is expected that with the PBL they develop this competence only 45, 76 % of students as evidenced in figure 5 expressed their liking for collaborative work, while 15.04% expressed their displeasure.

Figure 5. Disposition for collaborative work from the realization of learning projects in mathematics in students of the ESPOCH of the Software career.

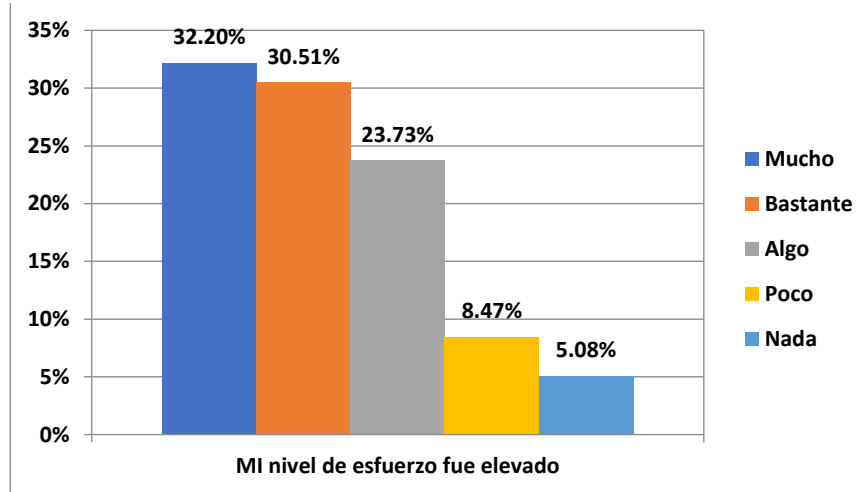


The success obtained in this research is similar to that obtained in the research carried out by Botella and Ramos (2019) where they found that PBL is a particularly appropriate methodology to enable positive feedback and teamwork strategies. In addition, it should be remembered that when positive feedback is provided, PBL serves as a mediator between the motivation of the teacher and that of the student.

Given the positive experiences when using PBL, authors such as (Cyrulies and Schamne, 2021), conclude that it is a didactic strategy that develops diverse problems in a collaborative way, and integral in various areas of knowledge, so it is of great need today that we are in a globalizing and challenging society, although it is true that PBL focuses purely on the student. On the other hand, a crucial participation of the teacher in the development of learning in an objective and challenging way is requested.

One of the difficulties manifested by students of different careers for learning mathematics is the complexity for their understanding, in this sense the results reported in figure 6, show that 62.71% of students de the career Software said to perform a high effort to carry out the project, while 13.55% said they solved it easily.

Figure 6. Level of effort for the realization of learning projects in mathematics in students of the E SPOCH of the Software career.

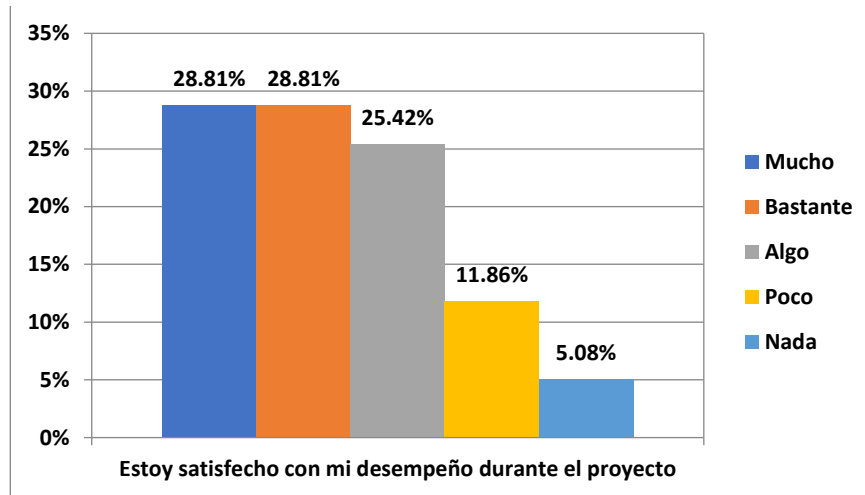


The difficulties observed in the students of the Software career for the learning of mathematics coincide with what was pointed out by Dorado and Díaz (2014), who affirm that they are not easy to learn, their learning requires the creation of abstract meanings, the coding and decoding of symbols, and the ability to build relationships at the level of the or possible, so PBL is a relevant strategy to be based on real situations.

Andrade (2011), states that when difficulties cannot be avoided, they become obstacles because they do not allow progress in the design of new knowledge and didactic obstacles are studied through the analysis of the most frequent errors of students. We will speak of error, at the moment that these students can not execute a task that is in a mathematical context.

Although the project carried out in the mathematical field required a considerable effort, 57.62 % of the students were satisfied with the performance achieved during the realization of the same as evidenced in figure 7, while that 15.94% said they were not satisfied with their performance, which will obviously be reflected in the academic performance observed during the course of the subject.

Figure 7. Level of satisfaction for the realization of learning projects in mathematics in students of the E SPOCH of the career de Software.

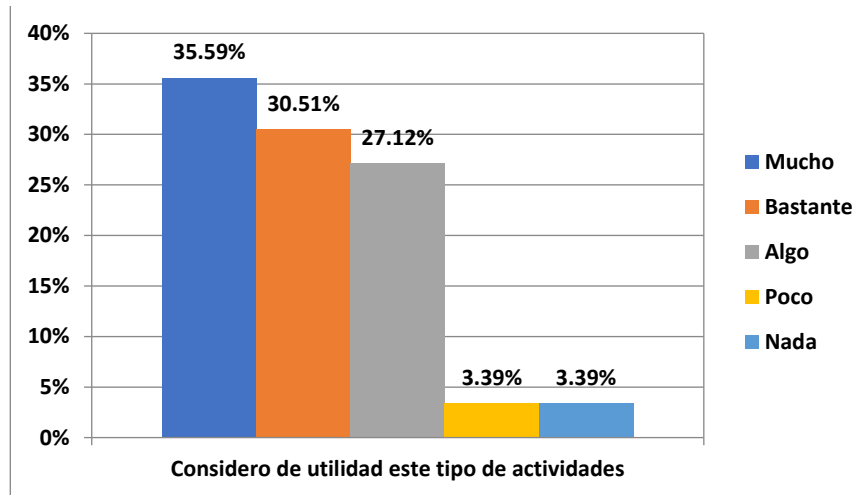


These results coincide with the findings of Zorrila et al., 2022 who arm when evaluating the level of satisfaction of students with respect to the methodology used, it can be affirmed that students are satisfied with the application of PBL methodology in the classroom, because they put their learning into practice to solve real problems, valuing with the highest score the items raised in the satisfaction survey.

Soria et al., (2019) points out that the levels of satisfaction are higher the greater the degree of involvement and participation that the teacher allows the students, both in the development of the theoretical contents of the subject, and in the evaluation of their level of achievement. This is accompanied by a much greater degree of involvement when it comes to offering students total control over the development of learning content, always with the guidance and supervision of the teacher, who accompanies the student in his process of acquiring knowledge.

One of the most valued aspects and that could be related to the interest and motivation for the study of mathematics, is the usefulness that can be given to it in the field of professional performance, in this sense in figure 8, it is observed that 66.07 % of students perceived that the use d e e Mathematics is useful, which was reflected in the projectand only 7.78% said that it has no use.

Figure 8. Usefulness of the realization of learning projects in mathematics in students of the E SPOCH of the Software career.



The results confirm what Bender (2012) affirmed, proyectos based learning (PBL) is the most effective way to involve students in learning, since students actively participate in the selection of many aspects of their tasks, assignments or assignments, in addition to being motivated by real-world problems related to their community and their interests; therefore, Research projects that cover all possible subjects and that get the student to see the usefulness of what they work on in class must be encouraged, which is usually the main cause of loss of interest

The usefulness of mathematics understood from PBL is consistent with what was stated by BenJumeda et al., (2015) highlighted the potential of PBL to promote mathematical literacy processes, mainly those related to the application of knowledge and mathematical modeling. They stressed that most students recognized the usefulness of the learning acquired.

Level of achievement

A greater motivation, interest, understanding and positive perception towards the learning of mathematics should be expressed the achievements achieved in relation to the objectives raised in the curricular unit, in this sense in Table 3, it is observed that 67.24 % includes the contents taught, 64.91 % make correct use of the rules of derivation and 66, 10% analyze and interpret adequately the results obtained, from the negative point of view in Table 3, it is also observed that only 6.90 % of students do not understand the contents, 7.02% make incorrect use of the referral rules and 8.47% analyze and inadequately interpret the results

Table 3. Level of achievements achieved after the realization of learning projects in mathematics in students of the ESPOCH of the Software career.

Assessment	Comprehension	Using bypass rules	Analysis and interpretation of results
Correct	67,24	64,91	66,10
Moderately correct	25,86	28,07	25,42
Wrong	6,90	7,02	8,47

A higher level of achievement in learning mathematics together with a better academic performance of Software students, as observed in a slight increase in the average of grades and the increase in the number of passes and reduction of failures as observed in Table 4.

Table 4 Performance of mathematics students of the Software career after the use of project-based learning strategies.

Using APB	Grade point average	Passed (%)	Failed (%)
No	9,85	55,80	44,20
Yes	10,61	64,30	35,70

The results coincide with what was pointed out by Morales and García (2015) who affirm that an increase in the grades achieved by students by this method of work (PBL) make a better scope of the knowledge put in escenena in the trimester is perceived, so they conclude that techniques should be encouraged of learning that encourage true learning and not a simple reproduction of texts, which does not promote an interest of the student to build their own knowledge.

In this same sense, Herradas and Byears (2018) point out that cooperative learning is an appropriate methodology for the teaching of Mathematics, since it favors the acquisition of competences and improves the academic performance of students, regardless of the educational stage, compared to the Traditional methodologies, based mainly on the lecture and in which students memorize the contents, are not very effective in providing students with the required skills and abilities.

CONCLUSIONS

It was observed that the use of PBL for the learning of mathematics in the field of the career of Software allowed an adequate use of the rules of derivation, for the analysis and interpretation of information real, which It allowed to understand the usefulness of mathematics in the work context, which increased the interest and motivation of students towards the study of them.

Although a better student performance in learning mathematics was observed after the use of PBL, it is still observed that students perceive that they must make a great effort to carry out projects in the area of mathematics, indicating that complexity in learning the s themselves remains one of the main problems.

The greater commitment in the learning of mathematics was associated with a greater motivation and interest of students to study them, which was expressed in better academic performance, which increased significantly to the compare the ratings of the academic periods in which the PBL tool was used compared with those in which it was not used.

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