The use of technology and academic performance in the teaching of Mathematics in secondary education

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Abstract: *Technological resources in secondary education have had problems in their implementation, especially in public institutions, this has caused teachers to keep traditional learning methodologies, with minimal alternatives to use active methodologies due to the limited access to Information and Communication Technologies (ICT). The present research aims to analyze the use of technology and academic performance in the teaching of Mathematics in the Joaquín Lalama Educational Unit. The methodology applied had a quantitative approach, with a pre-experimental experimental design and a pretest and post-test level of analysis, with the participation of 58 first and second year high school students; direct observation and inquiry were used as techniques. The results obtained indicated that 86.2% of the students consider that they learn better when the teacher uses a traditional class; 93.1% stated that they would like to learn Mathematics with the use of technology; on the other hand, 24% of the students mentioned that teachers never use a scientific calculator in their classes and 71% and 79% stated that teachers rarely or never use a projector or software, respectively. For the application of inferential statistics according to the characteristics of the variables and the hypotheses proposed, Student's t-test for related samples was used, obtaining p-values of less than 0.05, which means that the use of technology through the application of Inquiry Based Learning (IBL) establishes significant differences in the academic performance of students. The IBL has generated an increase in academic performance at the time of the pretest and posttest analysis; 0.696 points in the average.*

Keywords: Technology, Academic Performance, Inquiry-Based Learning.

INTRODUCTION

Education has had a continuous evolution in methodological and pedagogical aspects through the incorporation of technological resources or tools that have improved educational quality standards in secondary education institutions. In addition, the incorporation of new methodological strategies by teachers has improved the teaching and learning processes of students according to the skills with performance criteria and evaluation indicators located in the micro-curricular planning.

Education at the national level is structured by fiscal, private, fiscal-commissioned and municipal educational systems, each of which has different realities. The fiscal institutions are those where there are deficiencies in the teaching and learning process of students and that directly influence their academic performance. Each subject that is taught has different strategies, but those that are part of the exact sciences such as mathematics are the most disadvantaged due to the complexity and level of understanding by students.

Mathematics is a difficult subject for students to understand, in many cases they do not have affinity due to the frustration that arises at the time of the development of the exercises or problems posed. By keeping a traditional class, teachers maintain the students' lack of interest in understanding and comprehending mathematics; therefore, it is important to use strategies that adapt to the students' cognitive abilities. Currently, students have an affinity with the use of technology, therefore, incorporating the progressive use of Information and Communication Technologies (ICT) would capture their attention.

The methodological processes currently used in the Ministry of Education have generated controversy in the educational field due to the lack of resources needed to turn the teaching and learning process around, with the aim of gradually improving the performance of teachers and, above all, educational quality standards.

LITERATURE REVIEW

Education has evolved in technological and pedagogical aspects in different areas of knowledge. Talking about exact sciences such as Mathematics is essential to improve cognitive aspects with emphasis on logical reasoning and critical thinking. Currently, the use of technology as an intermediary in the teaching and learning process has become indispensable to improve the general knowledge of young people, who seek to understand and comprehend why it is important to have skills in this type of subjects. For Calcines et al. (2016) mention that "the integration of ICT plays a dual role: on the one hand, it contributes to the improvement of results and, on the other hand, it has a decisive influence on them, because it substantially stimulates the motivation of students towards learning" (p. 43). The use of technology can interfere in the educational process to reinforce students' knowledge in a playful, interactive and efficient way.

Technology must be properly addressed in a classroom and depends on the objectives that the teacher wishes to achieve, therefore, a structured planning with adaptation of ICT and active methodologies according to the needs, benefits the teaching and learning process, and the academic performance of students. For James et al. (2022) "the use of multimedia tools is considered an important contribution to teaching and a highly influential instrument for acquiring knowledge, in which students actively contribute to the elaboration of knowledge and value their own learning" (p. 18). Any technological tool, through its proper use, can be applied to generate significant learning, in addition, fostering a culture with ICT criteria causes young people to incorporate investigative and inquiring aspects that benefit their academic training.

Teachers are familiar with technological tools or environments regarding the preparation of annual and micro-curricular plans, so that the teaching role involves the constant use of ICT for professional development and fulfilment of obligations. The continuous training of teachers in technological topics can enrich their personal knowledge and the students they are in charge of. On the other hand, Falcó et al. (2016) are of the opinion that "teachers turn to the Internet mainly in search of resources and use technologies to design activities, attend to diversity, collaborate with other teachers and manage classroom work" (p. 84).

Specific characteristics of ICT with a focus on Mathematics

The use of ICTs in Mathematics has particular characteristics in the teaching and learning process, which must be well defined for its application. It is advisable that the teacher who teaches this type of subjects masters the technological resources that are adapted to the needs of the students and are articulated to the skills established in the class planning. According to Espinoza and Rodriguez (2021) establish several reasons why ICTs should be considered at the time of their application:

- It improves the development of critical thinking.
- It improves problem-solving skills.
- It benefits the materialization of theoretical and practical knowledge.
- The application of software in Mathematics helps in the analysis and interpretation of the problems posed.
- It improves the interaction between teacher and students in exploratory and experimental aspects.
- It promotes the use of active methodologies directed to inquiry and research.

ICT and academic performance

The use of ICT does not ensure a total improvement in the academic performance of students in the subject of Mathematics, but it implies a development in the growth of skills for the understanding of knowledge. However, interactivity through computational aspects captures the attention of students, with much more reason, when gamification is used, it can generate significant learning that improves the participatory and reflective conditions of the student. It is important to have concentration in a class, therefore, the methodology is fundamental, although for Miguel-Revilla (2020) there are important aspects to consider and he mentions that "introducing educational technologies in schools has to do with the degree of motivation and involvement with which students face the classes, which may lead to wonder about the impact of digital tools" (p. 1130).

From another perspective, the use of ICT allows the student to inquire and have a better vision of the resource or technological tools, in addition, they have the ability to acquire skills that adapt to their learning and diversification in educational development. For their part, Pardo-Cueva et al. (2020) have a different conception and mention that "when different technological tools are incorporated into educational training, students have the ability to learn in different ways and at unequal rates" (p. 936).

Active methodologies in education

Active methodologies are alternative processes used in education to improve the teaching and learning process of the student, in most cases, various technological resources are used as a means of communication that allow the information to be received in an interactive and dynamic way, in addition, this type of methodologies has a systemic approach, that is, they are structured through sequential parameters with the purpose of benefiting the student in the construction of his own knowledge.

Inquiry-Based Learning

Inquiry Based Learning (IBL) is one of the active methodologies that should be applied in the teaching of Mathematics, for the simple fact that students must learn to generate an investigative culture in their training process. This type of methodology is adapted to the context of the exact sciences because it strengthens critical thinking, fosters the investigative culture, creativity, deepens experimentation, allows the establishment of hypotheses, adaptability to technology and the refutation of criteria in collaborative work, furthermore, for Sala and Font (2019) mention that IBL "highlights the importance of establishing a commitment to solve a problem, working collaboratively, discussing and dialoguing, considering alternative approaches with critical thinking and reflection on learning and communication" (p. 75).

Mathematics is a subject that students have long had complications in understanding, in several cases, causing frustration when analysing a specific topic. It is essential to apply learning methodologies that involve student autonomy with research criteria, and to accomplish this, inquiry is essential because it outlines the role of the student in cognitive development, reasoning and perception in knowledge. Using IBL is the starting point to change the students' ideology, therefore, for Huang et al. (2021) indicate that this methodology "is a pedagogical approach that emphasizes learning through experience and construction, in addition, it fosters students' autonomy in the learning process and involves learner-centered activities" (p. 1506).

IBL, when incorporated as a methodology in a classroom, creates basic skills in the student in order to construct his or her own knowledge. There are specific IBL criteria related to transmission, discovery and challenge throughout the teaching and learning process. The in-depth analysis of the criteria or descriptors is detailed in Table 1 and Figure 1 according to the different approaches of the methodology.

Table 1. IBL specific criteria.

Approach	**Transmission**	**Discovery**	**Challenge**
Viewed from the subject.	A given set of standardized knowledge and procedures. A set of universal truths and rules to be transmitted to learners.	A creative subject in which the teacher adopts a passive and facilitating role, expecting students to create their own concepts and methods.	A set of interconnected ideas that the teacher and student create together through discussion.
Viewed from a learning perspective.	An individual activity based on observing, listening and imitating until fluency is achieved.	An individual activity based on practice, exploration and reflection.	An interpersonal activity in which students are challenged.
Viewed from the teaching perspective.	Structure a linear curriculum for students; give verbal explanations and check for understanding through practice questions; correct misunderstandings when students do not grasp what has been taught.	Assess when a learner is ready to learn; provide a stimulating environment that facilitates exploration; avoid misunderstandings by careful sequencing of experiences.	A non-linear dialogue between teacher and students in which meanings and connections are verbally explored. Misunderstandings are made explicit and worked through.

Source: Adapted from García (2011).

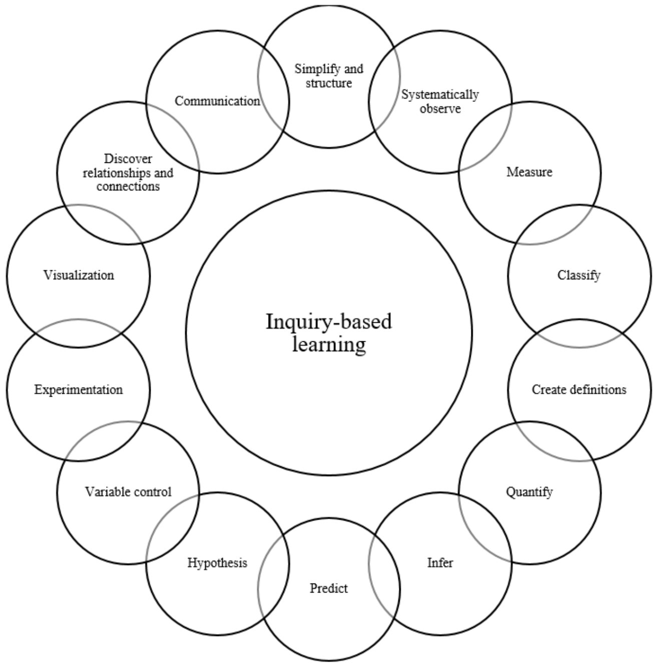


Figure 1. IBL Process. Source: Adapted from García (2011)

METHOD

Research approach

In the research topic, the quantitative approach was established, because the study variables use of technology (through the application of IBL) and academic performance are measurable and have their respective measurement scales, therefore, descriptive and inferential statistics were used for the analysis of the data collected, in addition, it is important to mention that when using statistical inference, hypotheses (null and research) should be raised in order to verify or contrast them.

Research design

It is important to define the research design to systematize the process to be followed in the methodology, for this reason, once the study variables were defined, an experimental design was established, this is because there is minimal control or manipulation of the variables. It is important to point out what was established by Palella and Martins (2012) where they state that "Not every educational situation is feasible or convenient to be treated experimentally, but when the circumstances are propitious and allow it, the experimental study should be applied" (p.85), therefore, being a research work related to the teaching of Mathematics as an exact science, applying an experimental design is feasible and beneficial for scientific development.

Type of research

In the educational field there are several cases where the study variables can be measured subjectively, and this depends on the form and context established by the researcher, having an experimental design it is important to minimize subjectivity in the study when analysing educational aspects, for this reason, the type of research was defined as pre-experimental based on the minimum control of the study variables.

Research level

Regarding the research level, a pretest and posttest analysis was established with a single group of students, the objective was to compare the traditional methodology currently used with respect to IBL as an active learning methodology. In this type of level, it is important to diagnose the current situation of the variables where there is an initial reference level before the intervention or treatment, after which a comparative analysis was performed in order to verify whether or not there is an improvement in the behavior of the variables.

Population and sample

In order to define the population with its respective representative sample, it is important to analyze the context or environment where the research is applied, and to consider the various resources that may be involved in the study. The researcher designs with inclusion and exclusion criteria the population and sample according to the ease of collecting the information. The current study, which was directed at students of the Joaquín Lalama Educational Unit, assumed that all members of the target population have the same characteristics based on the variables of analysis, that is, the principle of homogeneity.

As previously stated, a non-probabilistic sampling of census type and convenience was used, with all students considered in the study serving as a sample. For Hernández and Escobar (2019) on the intentional or convenience sample, they point out that “individuals are selected intentionally from the population to whom there is generally easy access or through open calls, in which people come voluntarily to participate in the study” (p.78).

The students included through a free and voluntary call to participate in the study were those who are part of the high school level in the first and second courses from the morning and afternoon sections, offered by the Educational Unit with a total of 58 students, who collaborated to perform the analysis of the current situation and verify the behavior of the defined study variables.

Data collection techniques

The techniques generally used in the research were direct observation and inquiry; the former was applied at the time of collecting the information because the facts were directly perceived by the researcher; and the latter was used when applying the IBL with the selected sample when executing the agenda established in the two subjects for the post-test analysis.

In addition, the survey and the evaluation test were considered as specific techniques with greater depth analysis for obtaining the data of the current situation; the first one had the purpose of measuring and correlating the items on the study variables, it had to be structured through the phases of preparation, design, analysis and presentation of results. This technique was applied with the purpose of knowing the level of usefulness of ICT (prospective studies) at the time of teaching Mathematics classes by the teachers of the institution; the second was used to verify the behavior of the students' academic performance at the time of the intervention with the application of the IBL in the post-test analysis.

Data collection instruments

Each of the specific techniques established in the previous section must be validated with its respective information collection instrument, for the execution of the survey, the questionnaire called "the use of technology and academic performance in the teaching of mathematics" was used as an instrument or tool, structured with two questions related to sociodemographic data and divided into three dimensions; The first dimension was designed with four questions about the previous inquiry on the use of technology; the second was structured with three items focused on academic skills in reference subjects; and finally, the third dimension consists of seven questions directed to the use of technology in the teaching process. It is worth mentioning that the different items were elaborated with dichotomous response alternatives and a Likert-type scale.

Hypothesis statement

H0: The use of technology through the application of Inquiry-Based Learning does not establish significant differences in students' academic performance (H1 = H0).

H1: The use of technology through the application of Inquiry-Based Learning establishes significant differences in students' academic performance (H1 ≠ H0).

RESULTS

Survey results

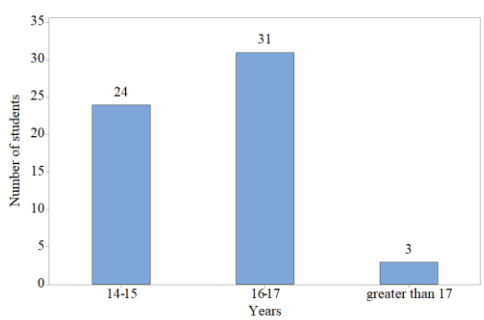


Figure 2. Age

Figure 2 shows that most of the students who took part in the study were between 16 and 17 years of age, with 31 cases specifically. In general, this age is in line with the educational level, this is due to the fact that the study was conducted in the first and second levels of high school. Knowing the age in an investigation is fundamental to establish the characteristics of the sample and to categorize the information according to the study variables.

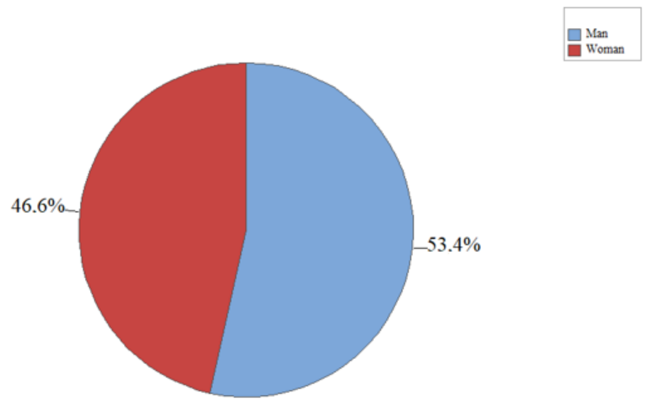


Figure 3. Genre

Figure 3 shows that the participants were selected equally, with 53.4% (31 cases) representing males and 46.6% (27 cases) females. Inductive and deductive thinking in adolescents are different according to the sex of the individual, from the point of view of Morales-Bautista and Díaz-Barriga (2021) refer that "critical thinking requires problematization, in which skills such as analysis, evaluation, and argumentation are involved" (p. 3).

Dimension 1: Prior inquiry into the use of the technology

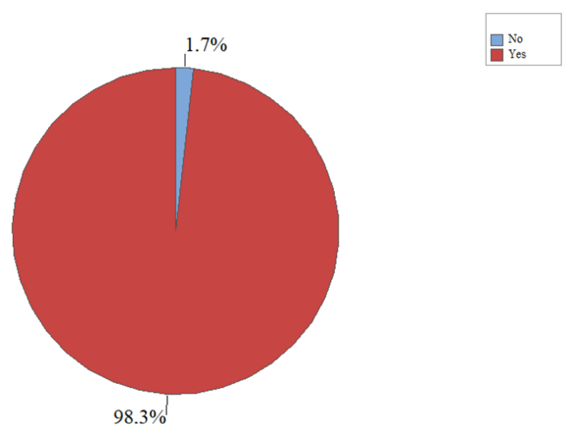


Figure 4. Taste for technology

In Figure 4, it is observed that students are attracted by the use of technology, this represents 98.3% (57 cases) of the respondents, while 1.7% (1 case) consider the use of technology unnecessary.

González-Ramírez and López-Gracia (2018) ratify that "psychological and personal well-being is the main reason why adolescents interact and manage the use of the Internet and social networks" (p. 74).

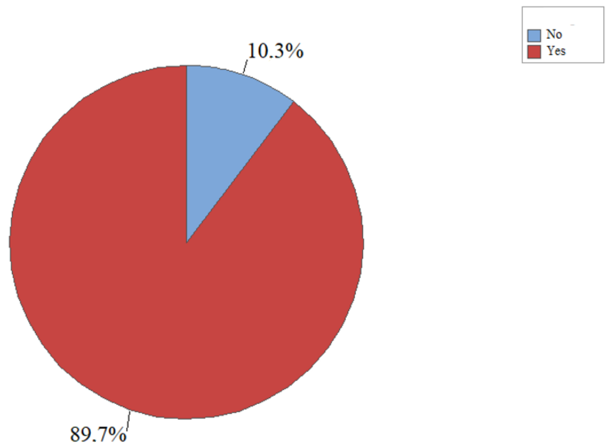


Figure 5. Internet availability

In Figure 5, 89.7% (52 cases) have internet at home, on the other hand, 10.3% (6 cases) do not have this resource. Madrigal and Contreras (2016) argue that "the internet continues to occupy one of the highest positions within the sources that adolescents access to search for information they find interesting" (p. 15).

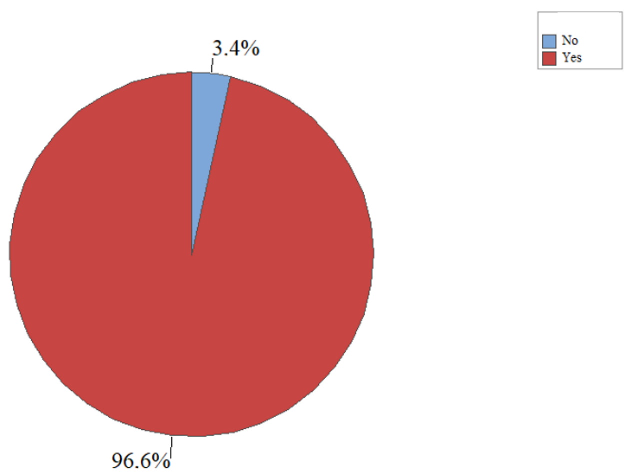


Figure 6. Knowledge of social networks

In Figure 6, 96.6% (56 cases) of the students know about social networks at present, while 3.4% (2 cases) lack information. The registration of users in social networks has had a considerable growth and especially in the adolescent stage (Rojas-Jara et al., 2018).

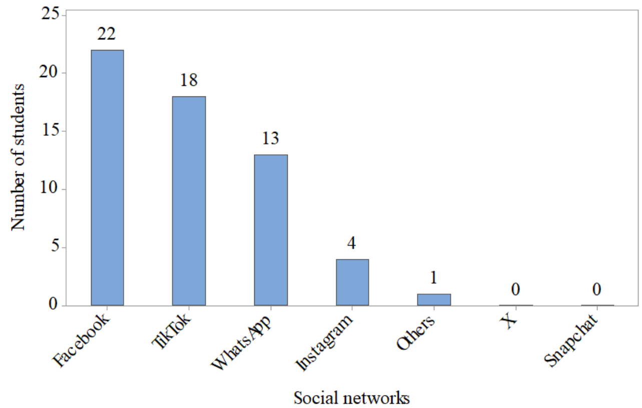


Figure 7. Most used social network.

Figure 7 shows that the social networks most used by students are Facebook, TikTok and WhatsApp with 22, 18 and 13 cases respectively. For Santillán-Lima et al. (2019) "social networks are a medium that propitiates interpersonal communication among students immediately and positively influences their academic performance" (p. 27).

Dimension 2: Academic skills in reference subjects

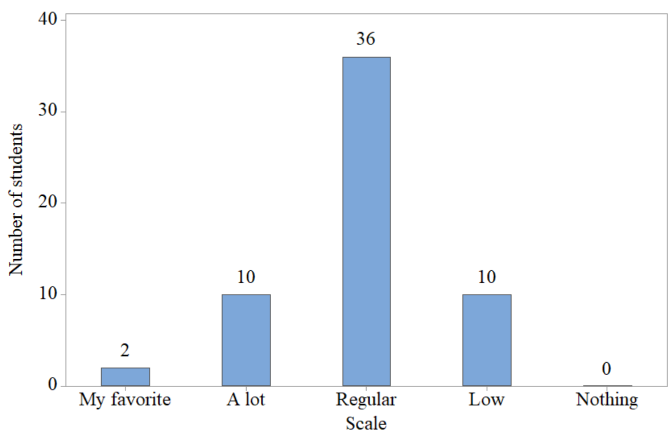


Figure 8. Interest in Mathematics subjects

Figure 8 shows that the students' interest in the subject of Mathematics is on a scale of regular with 36 cases, in the scales of very much and little there are 10 cases for each, and only on 2 occasions is it mentioned as a subject of preference. It can be concluded that the degree of interest in the mentioned subjects is minimal with approximately 21%, a worrisome case that should be analyzed in depth with methodological intervention.

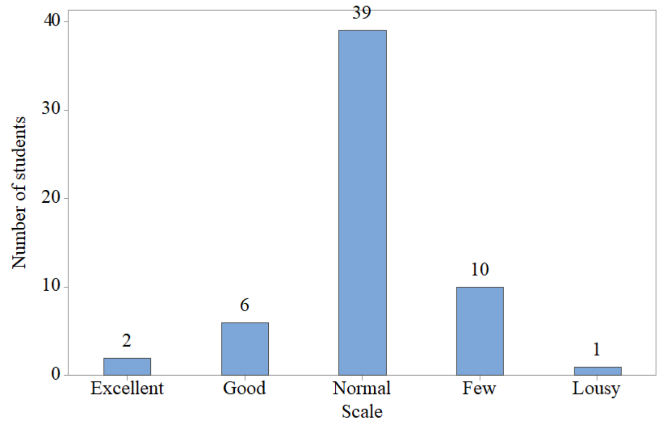


Figure 9. Mathematics Subject Matter Skills

Figure 9 shows that the skills in the analysis subjects are considered as normal with 39 cases, in addition, it is indicated that there are 11 cases distributed in the scales of few and very bad, and only 8 cases consider that they have excellent and good skills. In percentage terms, approximately 14% of the students state that they have acquired sufficient skills in the subject of mathematics.

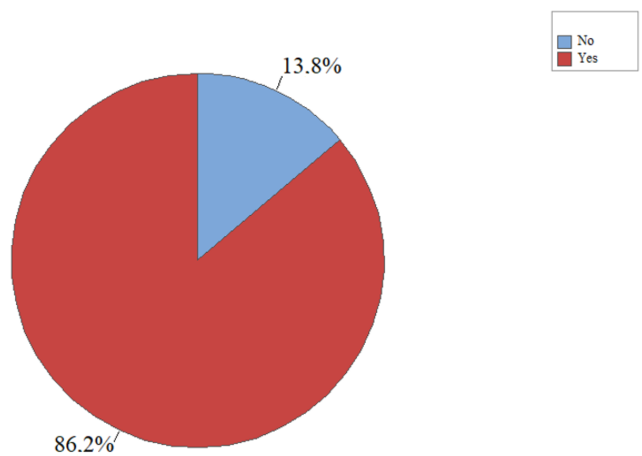


Figure 10. Criteria for a traditional classroom

In Figure 10, 86.2% (50 cases) of the students consider that they learn in a better way when the teacher uses a traditional class, on the other hand, 13.8% (8 cases) indicate that a traditional class has generated a delay in knowledge and especially in subjects that belong to the exact and experimental sciences. The use of ICT has become indispensable in the teaching and learning process, from the point of view of Velasco and Vizcaíno (2020) describe that "the use of ICT will make learning activities more dynamic, meeting the needs of forging innovative people" (p. 160).

Dimension 3: Use of technology in the teaching process

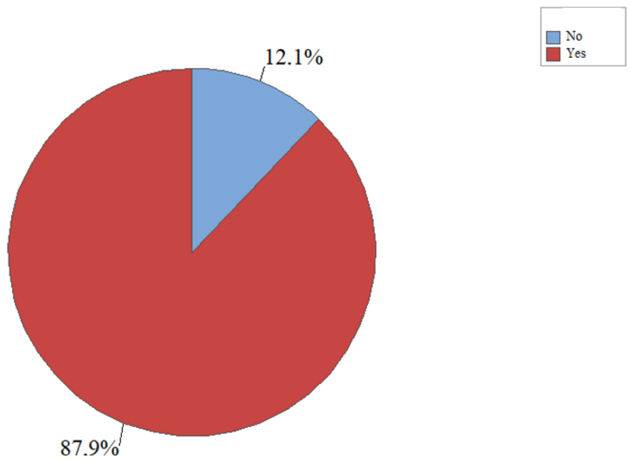


Figure 11. Criteria for a traditional classroom

In Figure 11, 87.9% (51 cases) of the students indicate that it is important for Mathematics teachers to use technological tools to improve their learning, while 12.1% (7 cases) mention that the use of ICT is not indispensable when receiving classes. According to Coloma-Andrade et al. (2020), they state that for teachers "the assessment and evaluation of these tools becomes extremely essential, since they do not have sufficiently solid criteria to encourage their use, so they are not motivated to bring these elements to their classrooms" (p. 205).

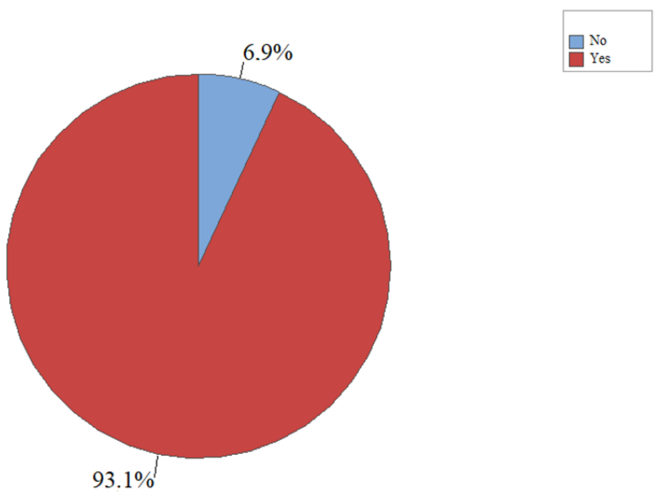


Figure 12. Interest in learning with the use of technology

In Figure 12, it can be observed that 93.1% (54 cases) of the surveyed students indicate that they would like to learn Mathematics with the use of technology, on the other hand, 6.9% (4 cases) do not agree with acquiring knowledge through the application of technological resources. Based on

Uvidia-Rodríguez (2019), the use of ICT "originates a high percentage of motivation in the learning of mathematics in students and provides the necessary elements for them to develop in this virtual environment" (p. 239).

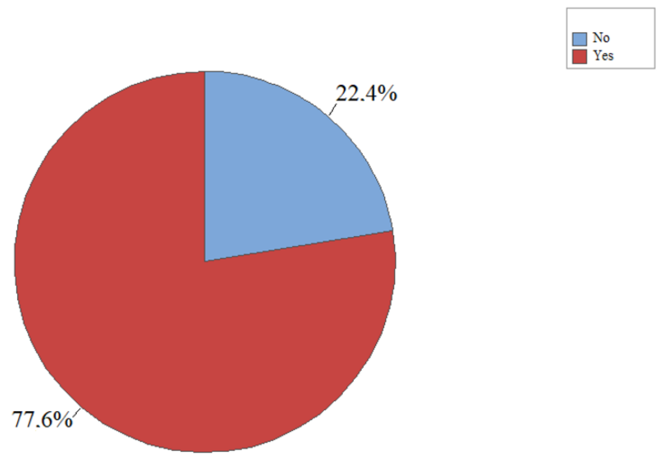


Figure 13. Teachers' use of technological tools

Figure 13 shows that 77.6% (45 cases) of the students express that Mathematics teachers have used technology in their classes; on the other hand, 22.4% (13 cases) indicate that teachers have not incorporated any technological resource at the time of teaching classes.

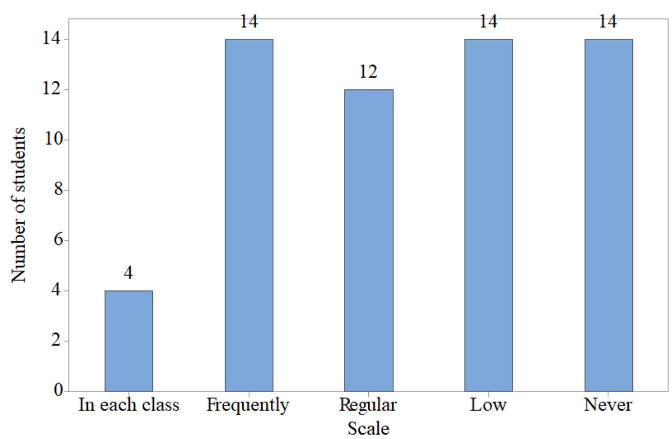


Figure 14. Use of the scientific calculator

The use of the scientific calculator has become a fundamental tool for verifying the results obtained in the resolution of mathematical exercises or problems. In Figure 14, it can be identified that the highest concentration of data is found in the scales of frequently, rarely and never, each with 14 cases. In percentage values, 7% of the surveyed students mention that the teacher has used a scientific calculator in each class, while 24% indicate that this tool has never been used. Mendoza-Alonzo (2019) refers that using a calculator "makes it possible to develop and strengthen important general skills such as estimation, mental calculation, the search for regularities, creativity, spatial vision and mastery of basic operations" (p. 50).

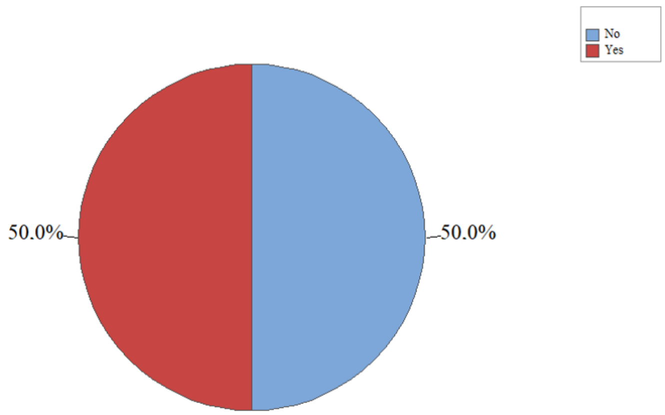


Figure 15. Explanation to students on the use of the scientific calculator

At the high school level, the use of the calculator becomes an indispensable technological tool, with more emphasis on the subject of Mathematics. In Figure 15, it can be observed that 50% (29 cases) of the students state that the teachers have explained the use of the scientific calculator; on the other hand, the same percentage indicates that the explanation on the operation of this tool has not been presented in the classes. According to Segarra (2022) "the calculator is shown as a useful tool in the teaching and learning process, especially as a support for independent work and that allows developing skills independently and creatively" (p. 3).

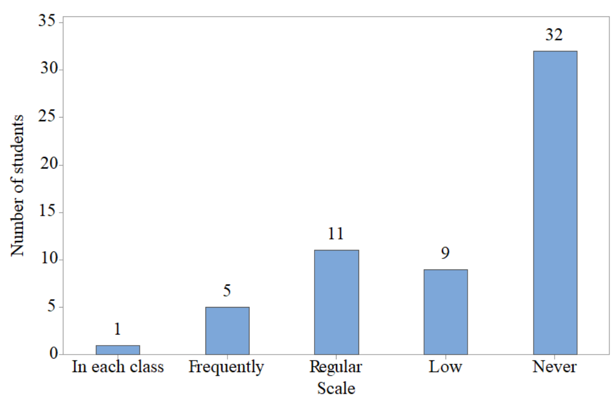


Figure 16. Use of the projector in Mathematics classes

The use of ICT in the teaching and learning process has become an indispensable and intermediary means for the understanding of a subject that needs to strengthen knowledge; in general, in subjects with high levels of difficulty, technological tools offer their potential and quality in the visualization of information. In Figure 16, the use of a projector has become a deficient aspect in the institution, where 9 and 32 cases indicate that its usefulness is in a scale of little and never respectively, this represents 71% approximately.

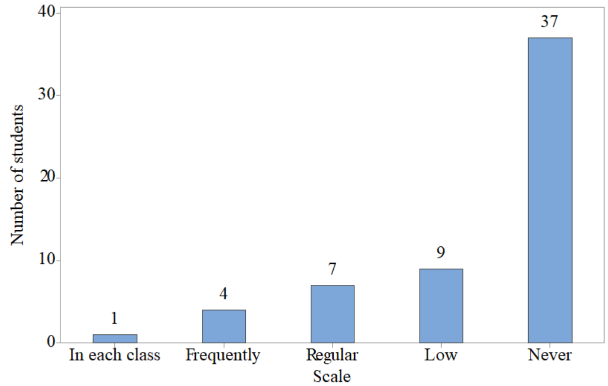


Figure 17. Use of the projector in Mathematics classes

There are topics in Mathematics such as equations, functions, descriptive statistics, among others, where the use of software should be aligned in the teachers' planning. Its importance refers to the interactivity and dynamism of incorporating these resources in classes so that students can generate greater adaptability, inquiry, creativity and innovation in the teaching and learning process (Morales-Olivera and Blanco-Sánchez, 2019). In Figure 17, it can be observed that there is a lack of applicability of software focused on Mathematics, where 9 and 37 cases indicate that its usefulness is on a scale of little and never respectively, this represents 79% approximately.

Pre-test result

In the application of the pretest, the teaching methodology used was a traditional class based on the ERCA technique (Experience, Reflection, Conceptualization and Application) where the only technological resource used was the scientific calculator. The topics selected for Mathematics were: systems of equations with the application of the methods of substitution, reduction, equalization and determinants; and descriptive statistics in relation to the calculation of the arithmetic mean for non-grouped data. After the contextualization of the theoretical foundations and the resolution of exercises or problems, we proceeded with the application of an evaluation of knowledge, where an exercise was established for each subject treated, four in total. The results obtained are detailed in Table 2.

Table 2. Averages through the application of the traditional class.

	Averages (points) without intervention			
	Student	**Mathematics**	**Student**	**Mathematics**
Experimental group	1	5.2	30	7.4
	2	7.4	31	9.1
	3	9.1	32	8.4
	4	4.7	33	6.4
	5	8.1	34	5.1
	6	7.5	35	6.2
	7	6.7	36	6.4
	8	8.4	37	8.8
	9	7.4	38	6.2
	10	6.1	39	6.8
	11	8.7	40	6.7
	12	8.1	41	6.4
	13	6.1	42	6.3
	14	6.1	43	6.7
	15	5.8	44	7.9
	16	9.6	45	6.8
	17	7.7	46	8.0
	18	9.4	47	7.2
	19	6.7	48	7.1
	20	9.1	49	7.0
	21	8.3	50	6.4
	22	6.4	51	4.8
	23	6.9	52	6.6
	24	7.9	53	6.9
	25	9.0	54	6.4
	26	9.7	55	6.3
	27	7.2	56	7.9
	28	8.5	57	6.5
	29	7.9	58	6.0

Post-test result

In the application of the post-test, the IBL was used as a teaching methodology, where the students received the classes in the Computer Science laboratory. The turning point of the IBL was the inquiry and its first step was the use of the YouTube platform as an online resource in the teaching and learning process. The functionality of YouTube was to inquire into the established topics in order to contextualize the theoretical and practical foundations in a generalized manner. The didactic platform Khan Academy was used to deepen the knowledge and materialize specific aspects of the topics, where the teacher helped to deepen the students' concerns using the role of mediator.

The functionality of the virtual simulators in the IBL was indispensable for the visualization of the information in an interactive way, the inquiry in this type of environments improved the understanding of knowledge in the students. For the verification of the results obtained in the resolution of exercises or problems posed, the online software Symbolab and Mathway were applied, in addition, Photomath as a mobile application in an alternative way for the same purpose in the comparison of results. At all times, inquiry was the intermediary technique for the materialization of information and discovery of analytical, deductive, inductive and investigative aspects by the students. See Table 3.

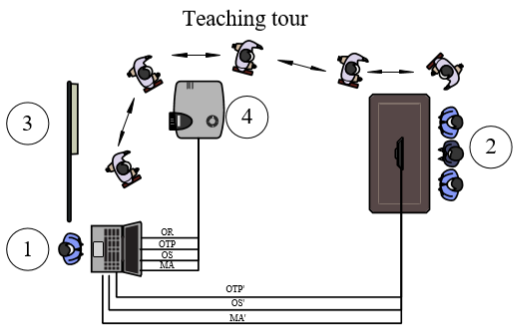
Table 3. Online elements used in the IBL application.

Element	Links
Online resource	• https://www.youtube.com/watch?v=LTfv1G2iYuQ&ab_channel=Matem%C3%A1ticasprofeAlex • https://www.youtube.com/watch?v=apPXOlZnRhg&ab_channel=Matem%C3%A1ticasprofeAlex • https://www.youtube.com/watch?v=0ilTVp5uRz8&ab_channel=Matem%C3%A1ticasprofeAlex • https://www.youtube.com/watch?v=jZIk90KQo6s&ab_channel=Matem%C3%A1ticasprofeAlex • https://www.youtube.com/watch?v=JwsfkIy6B_o&ab_channel=Matem%C3%A1ticasprofeAlex
Online software	• https://es.symbolab.com/solver/system-of-equations-calculator • https://es.symbolab.com/solver/arithmetic-mean-calculator
Online didactic platforms	• https://es.khanacademy.org/math/algebra-basics/alg-basics-systems-of-equations • https://es.khanacademy.org/math/cc-sixth-grade-math/cc-6th-data-statistics/mean-and-median/a/calculating-the-mean
Virtual simulators	• https://phet.colorado.edu/sims/html/equality-explorer-two-variables/latest/equality-explorer-two-variables_all.html?locale=es
Mobile applications	• https://photomath.com/en

Didactic component

For the understanding of IBL as an active methodology that adapts to the teaching and learning process of Mathematics, the following systemic process was applied for the established topics (Figure 18):

1. The teacher summoned the students of the experimental group to the computer lab, the students were distributed in groups of 3 per available machine (15 computers in total working properly).
2. The teacher conducted a discussion on the topics with the use of inquiry as a technique for the collection of prior knowledge provided by the students, the objective was to know the level of elementary knowledge and its prerequisites for the understanding of the class.
3. Once the teacher had conducted the prior knowledge inquiry, he incorporated and contextualized the topics of analysis in a generalized manner.
4. The teacher used the YouTube platform as an online resource in order students can watch the theoretical and practical explanation of the Edutubers, then a discussion was held with questions and answers of what was learned, where the teacher obtained the role of mediator.
5. The teacher shared with the students the Khan Academy page as an online didactic platform to deepen the theoretical and practical knowledge for the resolution of the exercises, each group made the respective inquiry of the platform where the participation of the students was the turning point. Collaborative work was indispensable in the process. Once the students had analyzed and investigated the information on the platform, the teacher provided feedback to materialize the knowledge.
6. The teacher presented and solved the exercises according to the established topics. At the time of the resolution, the teacher used the online software Symbolab and Wolfram Alpha in the free version to analyze and compare the procedure, as well as to indicate to the students the different resolution alternatives to obtain the same result.
7. Then, the teacher proposed the exercises so that the groups could develop and interact with the software shared in the classroom. The inquiry in the interactivity between computer and student groups remained latent at all times, where attention, observation and direct communication were indispensable in the teaching and learning process.
8. Subsequently, the teacher used Photomath as a mobile application to verify the result; only a photo of the exercise was taken and the result was automatically displayed on the mobile device, together with the resolution process. The groups carried out the same process with the exercises proposed by the teacher to verify the results.



Description
1. Teacher and computer.
2. Group of students and computer.
3. Blackboard.
4. Projector.

Meaning
(OR) = Online Resource - Teacher.
(OTP) = Online Teaching Platform - Teacher.
(OS) = Online Software - Teacher.
(MA) = Mobile Application - Teacher.
(OTP') = Online Teaching Platform - Students.
(OS') = Online Software - Students.
(MA') = Mobile Application - Students.

Figure 18. Didactic component of IBL

After explaining the topics through the IBL, the same knowledge assessment was applied again to determine the impact of the active methodology on the academic performance of the experimental group. The results obtained are detailed in Table 4.

Table 4. Averages through the application of the IBL.

	Averages (points) with intervention			
	Student	**Mathematics**	**Student**	**Mathematics**
Experimental group	1	5.9	30	7.9
	2	7.9	31	9.4
	3	9.2	32	8.6
	4	5.0	33	7.8
	5	8.6	34	7.2
	6	8.1	35	7.0
	7	7.1	36	7.5
	8	8.9	37	9.7
	9	7.8	38	7.4
	10	6.8	39	7.0
	11	9.2	40	8.5
	12	8.8	41	7.2
	13	6.7	42	7.9
	14	6.5	43	7.9
	15	6.5	44	8.0
	16	9.8	45	8.8
	17	8.2	46	10.0

18	8.7	47	7.9
19	7.9	48	7.5
20	9.8	49	7.5
21	8.8	50	8.3
22	7.1	51	7.1
23	6.3	52	7.4
24	8.4	53	7.2
25	10.0	54	7.6
26	10.0	55	7.9
27	7.0	56	6.4
28	9.0	57	6.8
29	9.1	58	6.3

Result of hypothesis testing

Since academic performance is a numerical variable that complies with a normal distribution, statistical inference was applied using Student's t-test for related samples based on the decision criteria of parametric statistics and for each subject established. The results are shown in Table 5.

Table 5. Student's t-test result for related samples.

Academic performance	t	df	p-value (bilateral)
Pre-test and post-test for Mathematics	-7.7	57	0.000

Note: t is Student's t-test for related samples; df is the degrees of freedom (n-1) and p is the significance level or bilateral or two-tailed error.

According to the results shown in Table 5, the application of the pretest and posttest in the academic performance variable with the IBL intervention through the use of technology has generated a p value of less than 0.05 in the subject of Mathematics, also with a t value of -7.7 with 57 degrees of freedom respectively. This indicates that according to the hypotheses stated, H0 is rejected and H1 is accepted where the use of technology through the application of IBL establishes significant differences in the academic performance of students.

DISCUSSION

The application of inferential statistics made it possible to contrast the hypotheses proposed by means of criteria and decision rules, and also helped to identify large-scale problems, especially in pedagogical aspects in the subjects that were part of the research before and after the experimentation. The usefulness and applicability of an active methodology such as IBL benefited students in the understanding and materialization of knowledge, where inquiry became the main axis at the time of analyzing the topics in the classroom. Students strengthened mathematical skills with the use of ICT and changed their role from direct observers to active observers (focused on inquiry) and participatory (focused on collaborative work).

The incorporation of any type of active methodology is fundamental to improve the teaching and learning process, it is a matter of the teachers of the different subjects, to investigate, analyze and understand each one of them for their correct implementation according to the requirements or needs in the class planning.

There are different didactic components that can be used in the teaching and learning process to improve students' academic performance and make the learning experience more attractive and effective. The following can be used as alternatives: feedback mechanisms (Forums using AI) to implement systems for students to receive instant feedback on their performance, allowing them to track their progress and make necessary adjustments; access to resources (Cloud Resource Sharing) with the aim of providing access to a digital library of mathematical resources, such as textbooks, articles and educational videos; assessment tools (Moodle) with the aim of developing online quizzes and assessments to evaluate student understanding and adjust instruction accordingly; teacher training (Technologies in Education Courses) to provide training modules and support for teachers to effectively integrate technology into their mathematics lessons, ensuring that they can maximize its educational benefits.

The applicability of IBL through the use of technology can be affected especially in rural areas, where connectivity is a drawback for both teachers and students in the execution of academic activities when using technological resources. According to the above, it is important to look for alternatives so that the core of IBL is reflected in the teaching and learning process. An IBL could be designed according to the available resources and needs of the educational institution, that is. a conventional IBL without losing the essence of using enquiry as a technique throughout the teaching process.

When designing a conventional IBL, the use of technology would cease to be the mediator in the entire teaching and learning process, but technological resources such as a scientific calculator or mobile devices (for the use of the calculator built into the device or another application that does not require connectivity) could be used to complement the conventional IBL process and are available to teachers and students who carry out academic activities, especially in rural areas. It is worth mentioning that the use of a scientific calculator and calculator as an application installed on the mobile device does not require internet access.

In subjects such as Mathematics, it is essential for ICT to be present at some point in the teaching and learning process, the purpose being that the student, apart from acquiring enquiry as a technique in the process of materialising knowledge, has the opportunity to obtain technological skills and become familiar with computational thinking.

CONCLUSIONS

The literature review has demonstrated the applicability of ICT in all educational fields, regardless of the subjects, technological resources or tools can be incorporated in the teaching planning at all levels. For exact sciences such as Mathematics, the bibliographic sources consulted have recognized the impact of ICT in the teaching and learning process, with an improvement in the understanding and comprehension of knowledge in the students of the different subjects applied and which has generated an increase in their academic performance.

In the previous analysis on ICT and academic performance through the application of the questionnaire, 87.9% of the students mentioned that it is important that Mathematics teachers use technological resources when teaching classes, 93.1% indicated that they would like to learn these subjects with the use of ICT, but 24% of the respondents mentioned that teachers never use a scientific calculator in their classes and 71% and 79% stated that teachers rarely or never use a projector or software, respectively. From the above, students are predisposed to use ICT in Mathematics classes, but by preserving traditional methodologies on the part of teachers, academic performance in these subjects has not improved in their averages.

The application of an active methodology such as IBL mediated by the use of ICT has improved study techniques in students, especially in aspects of inquiry, research and innovation, in addition, IBL has generated an increase in academic performance at the time of pretest and posttest analysis; 0.696 points. In the statistical inference analysis, it was verified by means of Student's t-test that further use of technology through the application of Inquiry-Based Learning establishes significant differences in the academic performance of students ($H1 \neq H0$), with a p value of less than 0.05.

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