



Management pedagogy: The addition in elementary school

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ABSTRACT

It's a study with a qualitative approach through action research. With the aim of teaching addition using the Mariela-Lehren-addieren method to students in 3rd and 4th grade. The Method of teaching addition is from the teaching of the basic skills of mathematical thinking, design and evaluation of the teaching strategy, the concept of number positional value, sign, concept of grouping, regrouping of numbers, the algorithm of addition, the practice of it with numerical exercises and reasoned problems. It is concluded that 18 students out of 21, achieved the learning of addition up to 4 digits with the Mariela-Lehren-addieren method through action research. It's inferred that the problems that arise in the learning of the addition, can be rooted by lack of systematic approach in previous educational cycles of the student, absences, learning problems, teaching models, motivation and school synergy.

Keywords: mathematical skills; arithmetic; elementary school; method Mariela-Lehren-addieren; educational lag.

INTRODUCTION

We are in a changing world that entails a change in mentality, development of critical thinking within the science of complexity and scientific research. Above all, a thought in which man is evolving to be better, being open to other opinions, new experiences, being more courageous in decision-making, innovating and making changes for prosperity in itself and for society. The effect of error and uncertainty, where the thinking is the main path to liberation of being. Consequently, man needs paths that lead him to a new discovery, to new methods for the path of investigation. Otherwise, to paths of evolution through metanoia.

Thought is a coming and going, like the search that is invented, built and rebuilt for periods of time, when the individual is open to these paths of change, that is, to mental evolution. This study is a path to one of the many forms of a method, in which researchers, academics, and those responsible for educational policies can take them into account to contribute to the teaching task in basic education, as well as teachers who carry out the practice of mathematics in the classroom.

Talking about the science of mathematics refers to problems, combinations, coordination and fusion of disciplines. This article is a study based on complexity, it intends to explain the theories in the teaching of addition in boys and girls from 8 to 10 years of age, of basic education, specifically to students of the 3rd and 4th grade, whose problem is that they have not finalized the subject of the addition. Meanwhile, reflect different theories and concepts of thinkers like Morín in multidisciplinary, in which many disciplines use them to explain others. Above all, an interrelation of disciplines such as Education, Pedagogy, Psychology, Biology, Philosophy and arithmetic.

The objective is the teaching-learning of addition, so that the student continues learning, concatenating arithmetic in their school world, for example, improving in the resolution of mathematical exercises of the addition.

This study will benefit scientists in the social sciences, basic education teachers, teacher training managers, sociologists, educational program managers, psychologists, among other professions. Likewise, empower students to solve problems that arise in their lives. Therefore, it is relevant in the teaching of addition, for a good academic base for subtraction, multiplication and division in the educational task.

There is an educational lag in basic arithmetic, a learning problem can influence other areas such as reading, writing, which requires a psycho-pedagogical diagnosis (Aguirre-Medrano and González-López, 2021). In which instruments are applied to detect problems in mathematics, which involves 26 tests of mathematical skills such as TEdiMath (Sueiro and Pereña, s.f.) and for reading the PROLECT-R (Cuetos et al., 2016).

The antecedent to this subject, the National Institute for the Evaluation of Education (2018) is in charge of the application of exams to basic and secondary education students in the subject of mathematics. According to this, the Presidency of the United Mexican States (2017), indicate that third grade boys obtained 31.8% and girls 31.1% of 100%, being an insufficient result in the subject (National Institute for the Evaluation of Education, 2016, cited by González-López, 2021; 2022).

This problem that students have come out with low percentages, may be due to the lack of mastery of basic arithmetic, the method used and the didactic and pedagogical strategies in the student body. Consequently, the teaching-learning of basic mathematical thinking skills combined for landing and development in the solution of mathematical exercises. Then from the numerical sense deficit, in the numerical precision-accuracy system, and the numerical approximation system (Aguilar et al., 2015); the macrostructure of the mathematical text as pointed out (Montero et al., 2020); and the negotiation of meaning, brokerage and simultaneous objects, are useful for analyzing the teaching of mathematics (Miranda and Gómez-Blancarte, 2018).

Problem Statement

As a result of the pandemic, many children from the institution located in Chihuahua have educational lag, among them are the students of the 3rd and 4th grade of basic education, who present difficulties in mathematics in terms of understanding the number, its representation, counting forward and counting back, the spatial location of the number, the place value of the number, problems of attitude towards mathematics, lack of development of mathematical thinking skills and the resolution of the problem of addition.

After an evaluation of each student in the third and fourth grade of basic education, it was identified that they have a low level in the area of mathematics, as the first moment of addition. Among other difficulties encountered, this study will only address the teaching of addition. Because this problem can lead to many problems in the present, and therefore, an intervention

program must be carried out for its improvement and for permanent learning during its educational stage, and a future dropout in other school grades and other problems must be ruled out, that may arise from these.

These students have a low socioeconomic level, most live with their parents who are workers, work in agriculture, livestock and one is an office worker. They live up to date, the school in which they belong is three teachers; each teacher has two educational groups. Therefore, the teaching task is doubled when planning and analyzing each student in each assigned task.

Justification

In the last 20 years, the cases of students who have difficulties learning arithmetic have increased, starting with the addition, although it has been said that the rights of children and adolescents is to have a quality education as pointed out by the National Commission of Human Rights (2021), that make them grow and develop integrally, as well as for permanent learning (González-López, 2021). Therefore, at school, teachers are responsible for situating teaching for the permanent learning of the student body, asserting their rights and responsibilities together with parents.

This research leads the way to support the work of teachers, students and parents so that there are advances in the difficulties faced by students in the third grade and fourth grade of primary school. This being a strategy of the school technical council of the institution. Currently, people need to be better prepared for present and future life, as well as complying with ethics, commitment and responsibility (Ramírez, 2007). Faced with a student body that has specific needs such as the lack of mathematical thinking skills and in this study 9 strategies are designed and applied for the teaching-learning of addition.

Theoretical framework for teaching addition

To support this research, the following studies are described that address different topics for boys and girls with learning problems in mathematics. External factors, such as poverty and gender, turn out to be the key factors that keep students away from school (Mendoza Cárdenas and Zúñiga Coronado, 2017). The difficulties in solving problems are based on reading comprehension, since it requires linguistic skills to develop concepts and processes in the application of mathematical rules or translation from one language to another (Magisterio, 2019).

There are different types of problems regarding learning in mathematics, of which can be rooted in 6 types of dyscalculia; verbal, practical, graphic, lexical, ideognostic and operational (p.1). They are distinguished by the lack of naming numbers, concepts, quantities, graphic interpretation, and difficulty in mental calculation and carrying out operations. In addition to acalculia, it is when the individual has learning problems in mathematics due to brain injuries.

The teaching of addition is based on the design, management and evaluation of a didactic sequence; it is through the method for the natural learning of mathematics, the guidelines for the design of learning activities and evaluation (Pantano Mogollón, 2014). On the one hand, Jaar (2021) carries out a study in which he obtains findings that show that the student body is motivated, and metacognition increases due to the effectiveness in implementing virtual learning environments and information and communication technologies.

The scholars Martínez et al (2019) analyze changes in the understanding of the process of addition between fractions as part of a whole from the use of rulers in children in the fourth

grade of basic education. On the other hand, the problems that arise in boys and girls in the learning of mathematics can arise when there are problems in the implementation of the type of teaching of the teachers, the errors, are due to a deficient learning of facts, skills and previous concepts (Nortes and Nortes, 2015).

The teaching of the operational mechanisms of addition must be imposed from the outside, from the understanding of the student as well as the rules of conventionality, concretizing it through didactic procedures different from the traditional ones in preschool (KamiI and Joseph, 1990). Next, Pincheira-Hauck and Vásquez-Ortiz (2018) mention that they evaluated aspects of didactic-mathematical knowledge for the teaching of mathematics, and infer different fundamental knowledge; the common knowledge of the content, the expanded, specialized and for the improvement of teacher training.

The importance of mathematics directs the individual to develop problem-solving skills in everyday life (González et al., 2017; Salmón, 2020; González-López, 2021a). They also help to identify, look at and interpret the world that surrounds students. Therefore, it is essential to take into account the language in which the lack of problem-solving skills influences and without these it causes frustration for students (Rodríguez and Domínguez, 2016).

METHOD

Action research leads the teacher to a reflective, cognitive and continuous learning pedagogy, as well as constant reflection in each step of the investigation (Pickard, 2013; Mertler, 2016). This methodology was carried out in five stages, each one focusing on the Mariela-Lehren-addieren technique in two age groups and in basic education that are in an educational lag, a problem in addition. Complexity is the problem that two groups of students of different grades have in solving addition math problems.

The teaching methodologic of the addition that I have called (Mariela-Lehren-addieren) in children of third and fourth grade of basic education, children between 8 and 10 years of age. This same approach can be taught to children under 8 and when there are students with an educational gap in children over 10 years of age. Given the importance of its follow-up for the addition domain (see figure 1).

1. Education: Two focus groups are included, one for the third grade of primary school, and the second for the fourth grade.
2. Pedagogy: Form of intervention in the teaching of addition, making a methodology to reach learning. Pedagogy elaborates the algorithm for teaching addition to lagging children of third and fourth grade of primary school. As Pantano (2014) mention that, the natural teaching of addition is to learn, using the mathematical algorithm of the same
3. Psychology: Developmental states of the two groups of students
4. Arithmetic: Main characteristics of the teaching of addition: example: concept of number, algorithm and practice of addition.
5. Philosophy: study elaborated and inspired from the perspective of other scientific researchers in their teaching philosophy and approach to this subject saw. Biology: detect anomalies or learning problems from the students' biology.

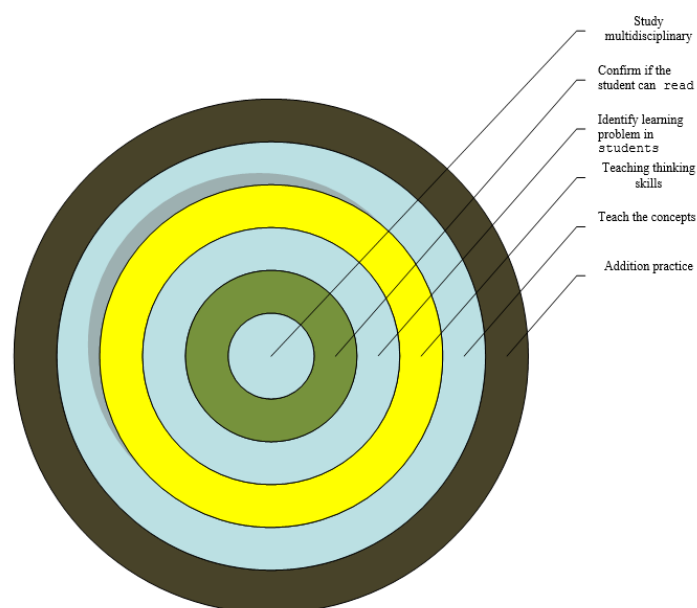


Figure 1. The addition teaching method called Mariela-Lehren-addieren.
Source: Own elaboration

The addition teaching method (Mariela-Lehren-addieren) is used as follows:

- 1) As an oral and physical interview on paper. Put the student to read and write.
- 2) Rule out a learning problem in the student, it is determined by reading and writing the student in five applied activities. Because of your physical or medical history.
- 3) Apply the thinking skills diagnostic instrument (González-López, Machin-Mastromatero & Tarango, 2020). Teach thinking skills and give examples (exercises on observation, classification, ordering, representation, description, analysis, evaluation and inference).
- 4) The concept of number and place value, knowing if you know what a number is and the value it represents.
- 5) The concept of the sign, knowing if the student knows the plus sign
- 6) Concept of grouping and regrouping numbers and its teaching, knowing if the student knows when to group in a sum and when to regroup.
- 7) Addition algorithm, if the student can carry out the steps to solve the sums.
- 8) Practice of addition with 1 to 4 digits, first they are taught with one digit, then two, three, and so on.
- 9) Practice of addition with reasoned problems focused on the student's context.

Population

This research was carried out with two groups of basic education; 15 children from the third grade and 7 from the fourth grade of primary school from August 2021 to January 2022.

Complexity

The term of complexity is handled as the problem that is being addressed, thinking about its solution with different disciplines or how to base it, address it and explain it (Morin, 2018;

Morin, Ciurana, & Mota, 2002). 15 students from third grade and 7 from fourth grade of basic education with general educational lag, such as addition, subtraction, multiplication and division, have been identified. In this study, the lag of the addition of 1 to 4 digits was focused. The problem in reading and writing the number, thinking skills, knowledge if it is subtracted or added, the sign and ignorance of the place value.

Diagnosis

The characteristics have been detected through a situational diagnosis in each of the students, which identified educational lag in both grades. Whose intention is to know what level of knowledge they had in arithmetic such as addition, subtraction, multiplication and division and the results obtained low results in the sign, grouping, regrouping, positional value and the realization of the addition. However, in this study only the teaching of addition is focused. The diagnosis of thinking skills identified a significant lag in the area of arithmetic. This research will only focus on the teaching-learning area of addition and the teaching of basic mathematical thinking skills, such as observation, classification, representation, inference, description, analysis, evaluation and decision making.

Teaching pedagogy

The teaching pedagogy is fundamental for the teaching of the addition, because it entails didactic and situational strategies for the students of basic education, in which it carries out its competences to situate the teaching-learning in each of the students. For this, he elaborates the algorithm for teaching addition. A method that was used to know the problem of addition is that an instrument was designed and applied to identify problems in student arithmetic. Material was designed to work on addition, such as: the hoop, the basket and the mathematical bowling alley. These materials were made with reused plastic milk bottles; the hose was obtained from cables, and reused bottle caps. Creativity and the creation of materials are essential for teaching addition, since it would be expensive for the teacher to buy the materials.

The teaching method is by direct communication and didactic learning, in which the student and the teacher exchange opinions, needs, projects and decide collaboratively how to carry out the process of strategies and reflect it orally or in writing. The teacher offers learning tasks, results and evaluation; negotiates with the student his plan and executes. Consequently, the didactic tasks designed for this study are: mathematical games, solving problems of horizontal additions, vertical additions, reasoned problems and mental calculations.

In terms of inclusion, the New Mexican School speaks of "adaptability as the ability to adapt education to the sociocultural context of students in each school" (La secretariat of public education [SEP], 2019a, p4; 2014). On the one hand, in article 61, inclusive education refers to the set of actions aimed at identifying, preventing and reducing the barriers that limit the access, permanence, participation and learning of all students, by eliminating practices of discrimination, exclusion and segregation (SEP, 2019, 61). On the other hand, the commitment of the teacher with his knowledge, values and attitudes to execute the intervention program for the student.

In basic education, for the teaching of addition, the Mexican study program is taken into account, in which it indicates the trait of the graduation profile, developing critical thinking, problem solving and mathematical thinking. Under the curricular standard for permanent learning and information management. Therefore, strengthen communication competence by developing the ability to communicate what you learn. Likewise, the formative field to which

the study is focused is based on mathematical thought, language and mathematical communication (SEP, 2017a; b).

Psychology

Knowing how children learn is a teaching task, and constant to situate teaching. Contemporaneity enriches the problem of the pertinence of psychology studies in the educational area, by offering possibilities to integrate models that try to understand human psychological nature and put it into practice, in order to improve the quality of life of students (Perez, 2007). In this study, the teacher applies child psychology to learn addition.

Biology

The biology of boys and girls in basic education are characteristics to carry out the teaching-learning task of addition, as a living being that lives and experiences emotions when learning this important topic, as a basis for their learning and research and who is scientific. Execute the method. Therefore, the student biologically and opportunely must be able to elaborate questions and obtain conclusions based on evidence in this case the addition, learn to solve them and carry them out in daily life, as well as communicate what they know. This learning involves teacher and family accompaniment

Philosophy

Aristotle's philosophy of mathematics allows us to approach both the methodological activity of the mathematician and the ontological status of its object from an ontological perspective, and insert both the method and the global theme of human knowledge in general (Martí, 2017). In addition to the philosophy of the teacher to teach-learning of the addition in boys and girls of the third and fourth grade of basic education.

Arithmetic

Addition is the mathematical operation or process in which the individual adds a quantity, and in which there are two or more addends from one to an infinite number (González-López, 2021). The concept of number arises from the mathematical and geometric, that is to say that the student must know a plural number, unit, number, a digit and the positional value. They have their origin in our concrete subjective acts, which seems to mean that such concepts are located on the psychological plane (Husserl, 1970 cited by Canela, s.f).

The model called "Mariela-Lehren-addieren" materialized for the teaching-learning of the addition was carried out with different strategies, described below:

- 1) Teaching thinking skills with examples: Observation, classification, ordering, representation, inference, comparison, analysis and evaluation.
- 2) Vertical addition, in which 1 to 4 digits are added as follows:

$$\begin{array}{r} \text{u m c d u} \\ 1258 \\ + 348 \\ \hline \end{array}$$

- 3) The bold letters mean the place value of each number in the addition operation: u for units, d for tens, c for hundreds, and um for units of thousands.
- 4) Horizontal addition as follows

$$\begin{array}{r} \mathbf{c} \ \mathbf{d} \ \mathbf{u} \quad \mathbf{d} \ \mathbf{u} \\ 258 + 10 \end{array}$$

- 5) Addition puzzle (figure 2). A table of 9 vertical sums is designed, and another one of answers of each scrambled with a puzzle of which each answer is forming the figure. The addition is done, and then the correct result of the second table of the puzzle is searched for and pasted into the operation that corresponds to it and so on until the puzzle is finished.

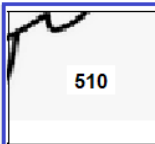

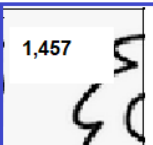






$\begin{array}{r} 1223 \\ + 234 \\ \hline \end{array}$	$\begin{array}{r} 89 \\ + 23 \\ \hline \end{array}$	9+8=			
$\begin{array}{r} 3456 \\ + 1000 \\ \hline \end{array}$	$\begin{array}{r} 2000 \\ + 1090 \\ \hline \end{array}$	$\begin{array}{r} 300 \\ + 200 \\ \hline \end{array}$			
$\begin{array}{r} 965 \\ + 459 \\ \hline \end{array}$	$\begin{array}{r} 9832 \\ + 3450 \\ \hline \end{array}$	$\begin{array}{r} 321 \\ + 189 \\ \hline \end{array}$			

Figure 2. Addition puzzle.
 Source: own elaboration

- 6) Reasoned problem example. Lola goes to the store and wants to buy two lollipops of different prices, the first costs 23 pesos and the second costs 12. How much will Lola have to pay for the two lollipops?
- 7) Crazy numbers table: A table of nine boxes is designed, 9 sums are dictated in different forms and the student writes his answer in a box until it is filled.
- 8) Mathematical basket: It is a mathematical game that was designed with plastic bottles, they were cut in half to form a glass, and adhesive tape is put on the edge so that children do not cut themselves when removing a tile when it is basketed. Then a 1.5 x 2 cm label with sums of 1 to 4 digits is placed on them. The token that is used are the bottle caps that were cut off. A distance of 1.5 meters is taken in which each child takes a token and in turns they throw their token into the basket, once basketed they review what sum they must solve and communicate it. Once it is solved, a point is scored and then the partner follows and so on.
- 9) Printed sheets were obtained from the Google network, the first was the activity of background figures, in which he indicated sums, so that the student could solve and according to his result the color that said piece should color, until forming a figure.
- 10) Crossword is a mathematical game in which the student invented ten sums and the answers had to be elaborated to form a crossword puzzle.
- 11) Oral mental calculation was asking simple exercises for example: 10+1, 100+10, 1000+2, 100+100 etc.

Strategy evaluation scales

- a) MB=addition dominates
- b) B=has many errors but solves the sum
- c) R= Needs accompaniment and must be taught again

Validation of strategies by the school zone inspector

The listed strategies from i-xiii were validated by the school zone inspector, making observations of well-structured and innovative strategies with content appropriate to the subject of addition and situation of schoolchildren. Since the research teacher designed them for the most part, thus being precise to carry them out in third and fourth grade boys and girls who have been defined as children with educational lag. Specify the inspector with a validity of .93 of 1 in its entirety.

- 1) The other half of the bottle (the neck of the bottle), the bottom of the neck is taped so that the student does not cut his fingers. Then a 1.5 x 2 cm label with sums of 1 to 4 digits is placed on them. Then a ring was designed with the plastic hose that was discarded from a cable for the internet, it is joined with tape to form the ring. Then 8 halves are placed neck up five feet apart for students to throw the hoop to score a sum. Once the hoop scored a sum, the student must solve it and communicate it. A point is scored and then the partner follows and so on.
- 2) Mathematical bowling is a mathematical game that was designed with disposable bottles (these were taken as pins), 10 were gathered and washed and 1.5 x 2 cm labels of sums from 1 to 4 digits were placed. Then a ball with a diameter of 15 cm was bought. Afterwards, a distance of 3 meters was taken so that each student could throw the ball by throwing it bowling and the pins that he threw, the student must solve each one and communicate it. A point is scored and then the partner follows and so on.

RESULT AND DISCUSSION

Result

1. Laboratory Importance Domains Evaluation

Practical activities, being a cornerstone of hands-on learning, receive acknowledgment from both groups, although with varying degrees of enthusiasm. Private school students, with a mean score indicating a moderate perception (around 2.97 out of 5), express a desire for more extensive or diverse practical engagements to enhance their understanding of scientific concepts. In contrast, public school students exhibit a significantly positive view (around 3.98 out of 5) towards practical activities, indicating a strong appreciation for the experiential learning provided in their laboratory experiences.

The assessment of laboratory conditions reflects similar trends, with private school students indicating a somewhat positive perception (around 3.05 out of 5), acknowledging the quality of facilities while also identifying areas for improvement. Conversely, public school students demonstrate a highly positive view (around 3.97 out of 5) of laboratory conditions, reflecting satisfaction with well-equipped and organized laboratory spaces that facilitate effective learning and experimentation.

When evaluating practicum scheduling, both private and public school students generally agree with the timing and frequency of practical sessions, albeit with slight variations. Private school students show a slightly higher level of agreement (around 3.17 out of 5), suggesting relative satisfaction with the current schedule but also room for optimization. Public school students express overall satisfaction (around 3.49 out of 5) with practicum scheduling, indicating that the timing and frequency of practical sessions meet their expectations while also recognizing opportunities for further enhancement.

In terms of report and evaluation processes, private school students exhibit a moderate perception (around 3.00 out of 5), indicating value in the reporting and evaluation of their practical work but also a desire for more comprehensive feedback or assessment methods. Conversely, public school students hold a positive view (around 3.56 out of 5), suggesting that they feel their practical work is adequately assessed and valued, contributing significantly to their learning outcomes.

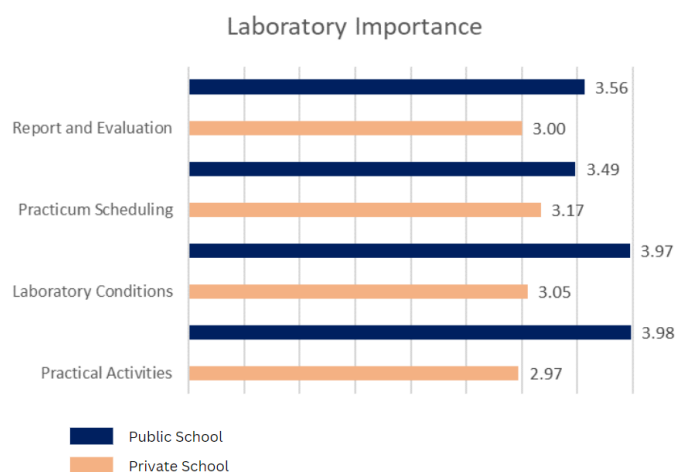


Figure 3. Summary of student perception towards laboratory importance

In examining the data for Practical Activities, significant differences in mean scores were observed between private and public school students across various statement items. For instance, private school students showed lower mean scores compared to public school students in several areas. Notably, public school students demonstrated a significantly more positive perception ($p < 0.000$) regarding the enrichment of biology learning through practical activities (statement X12) and the complementarity of laboratory activities with theoretical and practical lessons (statement X13). This indicates a higher level of confidence and appreciation among public school students for hands-on learning experiences and their integration with classroom teachings. However, both groups generally agreed on the frequency of biology practicum sessions (statement X14), with public school students expressing slightly higher agreement. These findings suggest a potential disparity in the perceived benefits and engagement levels related to practical activities between private and public school settings.

There were significant variations in the mean scores between students from private and public schools when the data for Laboratory Conditions was analyzed. Public school students consistently demonstrated higher mean scores compared to their private school counterparts across various statement items within this domain. Specifically, public school students exhibited significantly more positive perceptions ($p < 0.000$) regarding the presence of rules and regulations in the biology laboratory (statement X22) and the organization of tools and materials

based on their functions (statement X23). This suggests a higher level of satisfaction and adherence to established protocols and practices within the laboratory setting among public school students. Moreover, public school students also indicated a stronger acknowledgment ($p < 0.000$) of damaged equipment at the start of a practicum and its unchanged status (statement X24), as well as the availability of all necessary tools before a practicum (statement X25). These findings imply a greater sense of preparedness and reliability in laboratory resources and maintenance within public school environments compared to private schools. Data highlights significant differences in perceptions regarding laboratory conditions between private and public school students, with public school students consistently expressing more positive views and confidence in the organizational aspects and functionality of their biology laboratories.

When analyzing the data regarding Practicum Scheduling, distinct variations in mean scores emerged among private and public school students. Public school students generally demonstrated slightly higher mean scores compared to private school students across statement items within this domain. For instance, public school students indicated a higher level of agreement ($p < 0.05$) regarding the preference for multiple practicum sessions per week (statement X32) compared to private school students. This suggests that public school students may value more frequent practical engagements to reinforce their learning compared to their private school counterparts. Additionally, although not statistically significant, public school students also expressed a slightly higher acceptance of conducting practicum sessions in the afternoon after regular classes (statement X33) and agreeing to repeat failed practicums outside of class hours (statement X34) compared to private school students. These findings indicate a potential difference in flexibility and adaptation to scheduling challenges among public school students in the context of practical learning experiences. Furthermore, both private and public school students generally agreed on the importance of teacher guidance on certain subject matter before practicum sessions (statement X35), although public school students showed a slightly higher mean score. However, there was no significant difference between the two groups regarding supervision during practicum sessions (statement X36).

The data analysis of Report and Evaluation domain revealed interesting insights into the perceptions of private and public school students. Public school students tended to show slightly higher mean scores compared to private school students across statement items within this domain. This suggests a general positive outlook among public school students regarding the reporting and evaluation processes associated with practicum sessions. Specifically, public school students demonstrated a slightly higher level of agreement (although not statistically significant) with the requirement for a report for every practicum (statement X41) and the necessity of an oral or written test before or after the practicum (statement X42) compared to private school students. This indicates that public school students may perceive these assessment components as integral to their learning and skill development in practical settings. Additionally, while both private and public school students generally agreed on the importance of practical work being majorly assessed compared to theoretical evaluations (statement X43), public school students exhibited a slightly higher mean score in this aspect. Although not reaching statistical significance, this trend suggests a greater emphasis on practical skills assessment among public school students.

Table 1
Statement item responses mean difference

Statement Items	Mean score (Private School)	Mean score (Public school)
X11***	2.76	4.00
X12***	2.79	3.92

X13***	3.15	4.04
X14***	3.19	3.97
X21***	2.92	3.97
X22***	3.03	3.77
X23***	3.11	4.17
X24***	3.19	3.92
X25***	3.01	4.04
X31	3.12	3.44
X32	3.37	3.63
X33*	2.96	3.63
X34	3.25	3.33
X35	3.44	3.51
X36**	2.89	3.36
X41	3.05	3.50
X42	2.92	3.66
X43	3.03	3.53

* p < 0.1; ** p < 0.05; *** p < 0.000; Xs coded as **Error! Reference source not found.**

2. Biology Test Result

Mean scores of the biology test given shown that private school students achieved an average score of 65.6, while public school students had a slightly lower mean score of 62.85. This indicates that, on average, private school students performed slightly better in the biology test compared to their counterparts in public schools. Looking at the standard deviation, both groups had similar variability in their scores, with private school students having a standard deviation of 18.9 and public school students at 18.92. This suggests that the spread of scores within each group was relatively consistent. The upper quartile and lower quartile values provide insights into the distribution of scores. Private school students had higher upper and lower quartile scores (83.3 and 46.67, respectively) compared to public school students (73.33 and 46.67, respectively). This indicates that a larger proportion of private school students scored higher marks in the biology test compared to public school students. Examining the kurtosis and skewness values provides information about the shape and symmetry of the score distribution. Both private and public school students' score distributions showed negative kurtosis, indicating a relatively flat shape with less extreme scores compared to a normal distribution. Additionally, the skewness values close to zero suggest a near symmetrical distribution of scores for both groups, with no significant skew towards higher or lower scores.

Table 2
Biology test result

Biology Test Result	Private School	Public School
Mean	65.6	62.85
St. Dev	18.9	18.92
Upper Quartile	83.3	73.33
Lower Quartile	46.67	46.67
Kurtosis	-1.39	-0.721
Skewness	0.050	0.388

Interaction of Student's Lab Importance Perception to Bio-Test Results

The regression analysis results reveal important insights into the relationship between certain domains and student grades in Biology test questions, particularly within private and public school settings. One significant finding is related to Practicum Activity, where a notable positive relationship was observed for public school students ($\beta = 9.055$, $p = 0.053$). This indicates that increased involvement in practicum activities is associated with higher grades among public school students, although the level of significance is slightly above the conventional threshold of $p < 0.05$. Another significant finding pertains to Report and Evaluation processes, notably impacting public school students. Here, a significant negative relationship was found ($\beta = -6.97$, $p = 0.007$), suggesting that factors related to reporting and evaluation practices may have an adverse effect on student performance in Biology test questions among public school students.

Table 3
Regression analysis of laboratory importance

		unstd. β	S.E.	β	T-value	P-value
Practicum Activity	Private School	-1.868	3.083	-0.073	-0.606	0.546
	Public School	9.055	4.606	0.2	1.966	0.053
Laboratory Condition	Private School	-0.346	4.413	-0.01	-0.078	0.938
	Public School	0.839	4.931	0.017	0.17	0.865
Practicum Scheduling	Private School	1.302	4.48	0.035	0.291	0.772
	Public School	1.518	2.758	0.056	0.551	0.583
Report and Evaluation	Private School	3.254	2.875	0.138	1.132	0.262
	Public School	-6.97	2.527	-0.282	-2.758	0.007

The F-test results provide valuable insights into the relationship between the mean scores of Laboratory Importance domains and students' Biology test grades, categorized by private and public school settings. For private school students, the F-value of 0.464 with a corresponding p-value of 0.762 suggests a lack of significant relationship between the mean scores of Laboratory Importance domains and their biology test grades. This indicates that variations in how private school students perceive the importance of laboratory aspects do not have a substantial impact on their actual performance in the biology test. In contrast, for public school students, the F-value of 3.142 with a p-value of 0.018 indicates a statistically significant relationship between the mean scores of Laboratory Importance domains and their biology test grades. This suggests that how public school students perceive the importance of laboratory conditions, scheduling, and evaluation processes can significantly influence their performance in the biology test.

Table 4
Multiple regression analysis result

	F-value	P-value
Private School	0.464	0.762
Public School	3.142	0.018

Discussion

Various elements play a crucial role in shaping how students engage with and comprehend the subject matter. One key aspect is the diversity in teaching methods employed across private and public schools. For example, private schools may often adopt innovative teaching strategies such as project-based learning or collaborative group activities, which can encourage a deeper understanding of biology concepts and encourage critical thinking skills. Thus, students in private schools may get higher test results. On the teacher side, our note revealed that the pressure given by extensive evaluation by peer, headmaster, or the curricula administrative is another driving factor to improve their capability in teaching (Poster, 2005). In addition, some expressed that they would improve their self as a token of appreciation to the school administration that allow them to pursue their carrier. School strict administration may influence a subconscious encouragement to the teacher in order to meet the expected criteria lined by the upper administrative person. However, in management field, this may sound unrelated with common knowledge, as excessive burden might bring bad influence to the employee (in this case, teachers) (Heath & McCann, 2021; Milligan et al., 2022; Milosevic et al., 2020)

On the other hand, public schools might rely more on traditional lecture-based approaches, potentially impacting students' ability to apply theoretical knowledge to practical scenarios tested (Elfaki et al., 2019), especially in the biology test. Our observation and note from teachers' response revealed that due to the teaching experience, many express that their main achievement is to earn the certification or work experience as the basic requirement of public service registration. Additionally, some express that the salary was not enough to meet their expectations. Instead of improving their self by attending workshops or to take additional lessons about teaching, the money they earn just enough to support their day-to-day needs. In fact, most of the teacher we interacted are honorary employee. Moreover, differences in curriculum content and depth of coverage between private and public schools can significantly influence student performance. Private schools may have more resources to offer comprehensive and in-depth lessons on various biology topics, while public schools may face constraints that limit the breadth and depth of curriculum delivery which also related to their funds limit and allocations restrictions due to administrative factors. However, the fact that teachers in public schools often be trained by education-trainers, arranged by The Education Quality Assurance Agency (LPMP) under the Ministry of Education of Indonesia is another issue regarding our findings of the way of teaching in public schools.

Our findings align with the understanding that the diversity in teaching methods between private and public schools significantly impacts student performance in biology. Data reveal that private schools often employ innovative teaching strategies such as project-based learning and collaborative group activities, leading to a deeper comprehension of biology concepts and the development of critical thinking skills among students as it widely known in educational field (Bishop et al., 2020; McMahon, 2009). Conversely, public schools tend to rely more on traditional lecture-based approaches, potentially hindering students' ability to apply theoretical knowledge practically, as assessed in the biology test.

Factors such as teacher-student interactions, classroom environment, and motivation levels also contribute to student performance. For instance, supportive and engaging teachers who provide personalized attention and meaningful feedback can positively impact students' confidence and motivation to learn. Similarly, a positive classroom environment that promotes active learning, encourages curiosity, and fosters collaboration among students can enhance their overall learning experience and performance on assessments (Sugita & Takeuchi, 2010).

Our data strongly suggest that laboratory experiences doesn't play a crucial role in enhancing students' understanding and application of biology concepts. Private schools, as highlighted in our data, often provide well-equipped laboratories but supported with innovative teaching methods, focusing on other learning experiences that significantly contribute to students' knowledge assimilation and accommodation (Bishop et al., 2020). Practical activities supplemented with various and much updated learning sources and experiences, such as IT-integrated experiments and group projects, not only reinforce theoretical knowledge but also develop critical thinking skills, problem-solving abilities, and scientific inquiry among students in private school, where the laboratory importance is not in a very well acknowledged by the students (Mohd Elmagzoub Babiker, 2015; Scherer et al., 2019; York-Barr & Duke, 2004).

In contrast, public schools face challenges in providing comprehensive laboratory experiences even with better acknowledged by the students, as indicated by our findings. Efforts are made to optimize laboratory conditions, organize practical sessions, and integrate hands-on activities into the curriculum, though to a lesser extent compared to private schools. The significance of laboratory experiences extends beyond the assimilation and accommodation of theoretical knowledge. Our findings suggest that laboratory activities should promote deeper conceptual understanding, foster scientific skills development, and encourage active engagement in the learning process (Riswanto et al., 2019), but somehow failed to be meaningful to the student as seen on the bio-test.

Moreover, the positive impact of laboratories on students' knowledge is further amplified when combined with effective teaching methods, supportive classroom environments, and motivated educators (Broom, 2015; Solari et al., 2023; Tang et al., 2023). Our data point out the dependency of laboratory in public school as the one of the learning source and facility especially for biology in secondary high school.

Educational Policy Implications

Our findings have important implications for educational policy that should be considered in order to maximize resources and enhance student learning, especially when it comes to funding, particularly laboratory importance to support learning assimilation and accommodation in biology subject. Our findings demonstrate how inconsequential of having laboratories in school. As the learning world developed with better IT infrastructure and various learning source and method, the importance of having a physical and separated laboratory is questioned. Thus, proper funding for laboratory facilities, supplies, and equipment should be less priority in educational programs, at least in a public school (Cheng, 2022).

In private schools, where resources are relatively abundant, the challenge lies in ensuring efficient funds allocation to maintain the quality of laboratory facilities and activities without unnecessary overspending, or to improve the existing class with better IT-integrated learning facilities. Our findings suggest that private schools with worse laboratory perception by their students, resulted in better test result than the students in public school where they perceive better the lab importance (Poster, 2005). However, educational policies in private schools should emphasize strategic budget management to minimize unnecessary expenses while maximizing the impact of existing laboratory. Some subject matters might require physical activity such as traditional biotechnology (making tempeh, yogurt, scooby for kombucha, or other products).

One way to minimize funds allocation without compromising the quality of laboratory education is through effective education administrative practices. This includes regular assessment and evaluation of laboratory resources, maintenance plans for equipment, and optimizing the use of existing resources through collaborations with external partners or shared facilities (Pekkolay, 2021). Educational policies should also encourage innovative cost-saving

measures, such as digital simulations or virtual laboratories, to supplement hands-on experiences where feasible (Grace, 1995).

CONCLUSION

Private schools, despite scoring lower in their perception of laboratory importance compared to public schools, achieved better results in the biology test. This discrepancy suggests that laboratory experiences, while undoubtedly important, may not be the sole determinant of academic performance in biology. Other factors such as teaching methods, curriculum depth, teacher-student interactions, and student motivation likely play significant roles in influencing students' understanding and performance in the subject. While laboratories remain valuable educational assets, contribute to students' hands-on learning experiences, the impact may be influenced by various contextual and instructional factors within the educational environment, including teacher's hands-on influence on their students. However, the analysis did not include the socio-economic status of the students, as it may influence the way students learn and school resources quality.

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