IMPLICATIONS IN MATHEMATICS TEACHING, RHOCHREMATIC AND PAINTINGS IN THEIR STEPS INTERSTICES.

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DEDICATION

To family.

To my brothers, my sister, friends, grand- fathers (Roberto Arturo Vasquez Pereira, Victor Ceron Martinez Madrigal), grandmothers (Laura Escobar Henao, Francisca Rosa Vasquez Perez), great-great-grand-fathers, great-great-grandmothers, relatives, family, humanity, cosmos. To Dr. Fabio Vasquez Escobar. To the Most Excellent Bishop Gerardo Martinez Madrigal. To the Most Excellent Bishop Guillermo Escobar Velez. To the Excellent Ambassador Raul Vasquez Velez. To the Excellent Ambassador Lucelly Garcia Tobon.

To Marco Tulio Duque's School, Conrado Gonzalez Institute, IDEM Fray Julio Tobon Betancur, Colombian Polytechnic, National University, Autonomous Latin-American University, SEP, University of Antioch, Bolivian Pontifical University, UNAM, UAG, UNISARC, Sao Paulo University, Free University, Salvador Duque School, University EAFIT, University of Sydney, University of Helsinki, University of Tampere, University of Cape Town, TEC; University of Guadalajara, UCLA, MIT, University of Houston, Harvard University, Yale University, Oxford University, Linguaphone Institute, Cambridge University, Scranton University, UNESCO, DOMETAL, RIOTEX, COLTEPUNTO, Company of Packings S.A., Technological Institute. Pascual Bravo., Modern Institute of Education, ASSTI, ESAP, Colombian Polytechnic Jaime Isaza Cadavid, Montessori School, SENA, University de San Buenaventura, International Center of Cambridge, The St. Lukas Academy, Bamberg University, Pekin Normal University, Who's Who in the World, American Biographical Institute, The Marquis Publications, Editorial Papiro, Colombian Polymers, VIAMACOL, Rotary International, Biographical

Institute of United States of America, Superior Academy of Technical Industrial Services, National Service of Learning, Reforestation Company La Floresta, Casa de Reyes, Engineering School of Antioch, The Southern African Comparative and History of Education Society, University of Paris, Hospital El Carmen de Viboral, Beijing Normal University, Tokyo University, Waseda University. University of Guadalajara.

To the schools, institutions and universities of the five continents that offered me the opportunity to recreate, relearn, reinvent, rethink and study.

And to the whole last, present and future humanity that consecrates the cultivation of the right values, the positive visions, and life, is a great company, the post modernity, the fractality, the harmony of the societies and universal cosmos.

GRATEFULNESS AND RECOGNITIONS

To the whole last and present humanity
and their universal cosmos.

Recognition also to the M. C. Tonatiuh Bravo Padilla, Rector General, U. de G.; Dr. Marco Antonio Cortés Guardado, Rector CUC, U. de G.; to Dr. Remberto Castro Castañeda, U. de G.; to Dr. Jorge Tellez Lopez, U. de G.; to Bachelor Raul Padilla Lopez, U. de G.; Dr. Raul E. Tamayo Gaviria, Professor Vagn Lundsgaard Hansen, Professor Ching-Lin Hu, Professor Byung-Jin Lee, Professor Erwin H. Epstein, Professor Shin'ichi Suzuki, Dr. David Turner, Dr. Medardo Tapia U., MRS. Guadalupe Gonzalez de Turner, M.C. Jesus Cabral, U. de G.; M.C. Maria Morfin, U. de G.; Bachelor Maria Antonia Abundis, U. de G.; Bachelor Arturo Fernandez, U. de G.; Bachelor Javier Fernandez, U. de G.; M.C. Patricia Medina, U. de G.; Dr. Alfredo Cesar Dachary, U. de G.; Dr. Stella Arnaiz, U. de G.; to MRS. Barbara Bush, to Dr. Fabio Vasquez E., to Dr. Humberto Martinez V., to Dr. Guillermo Esquivias L., for their observations and comments.

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PREFACES

A long the time, the mathematics have had in an inherent form way the rigidity logic of know how to be with immanent properties that make from everythink a scientific circumstance of unlimited projections. Therefore that the employed methodology has a rational proper sense of a perfect structure in the conception of a whole singular creator of projects with a scientific character.

Therefore that the becoming times the man with attitude and logical capacity has figure out a the perfect concept called number which underlie in the depths of the knowledge. In this moment the door open for enter with the method, dedication and permanence sense in the concepts of the mathematical science and approach with seriousness to the totality of the human being and of the same object of knowing.

Therefore, that what has being shown in this book, presents with clarity in a conceptual level a mathematical methodology always agreed with the rigour of the self science and of the statistical inference.

For the citizen that's burst into pure knowledgeof the human being, it is clear that when approaching the abstract, finds the sublimity and the depth of a reason to be in the cosmos, the truth of a science with a structure and real and precise fundaments, basis for the innovation, creativity and formation of a knowledge every time more refined with an hermetic character.

Now we can conclude that is by the methods with a structural mathematical inference how we get with clarity to understand the truth.

Leonel Marulanda Masso
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INTRODUCTORY COMMENT

Many of us experienced the introduction of computers and the cybernetic systems during the sixties and now in the new millennium, we can observe a "before", a "during" and a "after", a rhochrematic (process of reprocess) process, a bring up to date for one practice of a Mathematics Pedagogy, a change for a transformation, a modernization for a justness and an action of developing the physical abilities, intellectuals for a positive vision and the necessity of systematizing the previous outlines.

We live in an era of too many changes in too short a time. We are living through cultural, accultural and cross-cultural processes. Where they are integrated cultures that plan per decades, case the Latin American. They plan for centuries, case the Anglo-Saxon. They plan for millennia, oriental case.

In view of this process and the paradigmatic ruptures that will take place in the next millennium, I present some methodological aspects of the practice of a Mathematics Pedagogy.

Present you some reflections and methodological restlessness of a Mathematics Pedagogy.

The first thing that should be made is to identify the problems, the fields, the limits them that the practice of a Mathematics Pedagogy has.

When identifying the problem they should determine the objectives or those "conductive threads" of the investigation, ("the compass") that should try to determine the variables and indicators that should be carried out to the conceptualization of the practice of a

Mathematics Pedagogy and be able to have integrative abstractions on time so that the "homo sapiens" is productive and that he developshis abilities, attitudes, values, virtues and positive visions in a balanced way.

n the conceptual foundation, they should make the revision from the literature in a world level of the Conceptualization of a Mathematics Pedagogy. Also it should keep in mind the present situations and future aspects, to have a panoramic vision, of warm total, of continuous improvement, reengineering, "benchmarking" and strategic planning in the abstraction of the practice of a Mathematics Pedagogy.

In the methodological alignment, it should be kept in mind the instrumentation, the inf ormation, the communication, the observation, the technology, either appropriate technology, adequate technology, transferred technology, or technology proper of each region to try to solve the current situation that is described in the problem.

I n the relating analytic, the proposed situation is presented, trials of continuous improvement are established, the advantages, the disadvantages, the pro, the contras, are shown for making a Conceptualization of the practice of a Mathematics Pedagogy.

In each region it has to be analyzed a "before", a "during", and a "after" of the rhochrematic processes, the investigative impacts, the interdisciplinary nature, the energy factors, entropic, negantropic, synergetic, homeostatic, exogenous and endogenous that each region this subjected one to their investigative and integrative advances with the "homo sapiens". Also the radio, the press, the television should be analyzed, the videos, the publicity, the INTERNET, the archaeology, other sciences and technologies that the "homo sapiens" consumes to carry out a diagnostic and an appropriate treatment toward an integrative vision of the "homo sapiens" so that he controls its technological-geopolitical advance.

In the conclusion, the representative ideas and power stations should be presented to try to solve the problems so urgent that the "homo sapiens" needs for his control transformer on a Mathematics Pedagogy and let us remember that the "homo sapiens" should have an integrative vision so that he controls his dynamic development for the future and depending on strategies of investigation that we have toward the Conceptualization of the practice of a Mathematics Pedagogy, is one way of building the futuresociety for next millennia.

Therefore, I invite you to you colleagues of the investigation to carry out the investigation in a world level of observing a "before", a "during", and a "after", of having a Conceptualization of the practice of a Mathematics Pedagogy.

If we are going to grow and to progress in our conceptualizations of the practice of a Mathematics Pedagogy, we should equip ourselves with the discipline and the necessary knowledge to be proactives with the threats, the weaknesses, the strengths and the opportunities of the future.

Our own survival and our well-being depends on our capacity to anticipated and to fight with the threats and future problems, to perceive, to evaluate and to control the effects of our actions and this way to be able to imagine and to create pedagogic futures more desirables.

Note: To page 23 to 39, the reader is left between the mentioned interpretation and paints for the reader to generate their own ideas and creative about. This is an exercise in creative writing and painting to generate new ideas.

OBSERVATION:

Rhochrematic process in electromagnetism pedagogy.

Discreet Variable

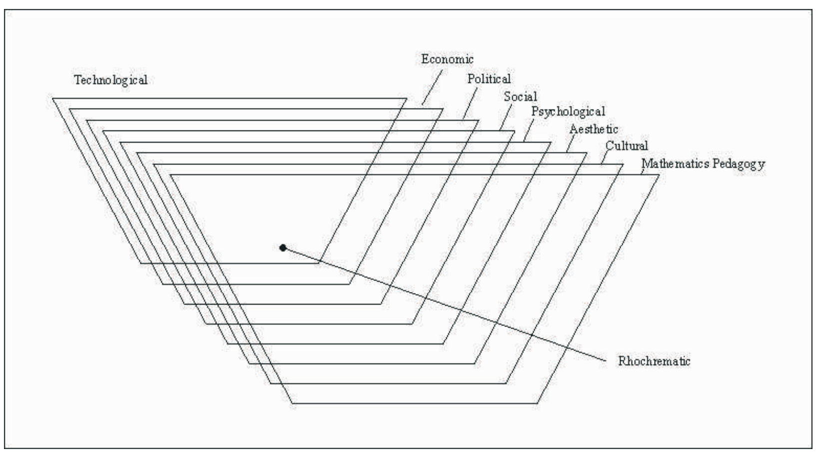
$$\sum_{b1}^{a1} x1 + \sum_{b2}^{a2} x2 + \dots + \sum_{bn}^{an} xn + \dots + \sum_{bk}^{ak} xk$$

Continuous Variable

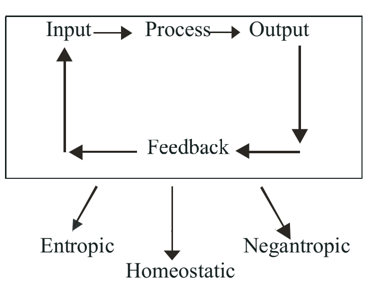
$$\int_{b1}^{a1} x1 + \int_{b2}^{a2} x2 + \dots + \int_{bn}^{an} xn + \dots + \int_{bk}^{ak} xk$$

Integrating the Rhochrematic process in electromagnetism pedagogy.

Integration System



Rhochrematic ⟶ The Process of Reprocess
Process System



$n_1 \dots n_2 \dots n_n \dots n_k$ with Discret Variable and Continuos Variable in the System

For any explanation, communication and questions to be placed in contact with:

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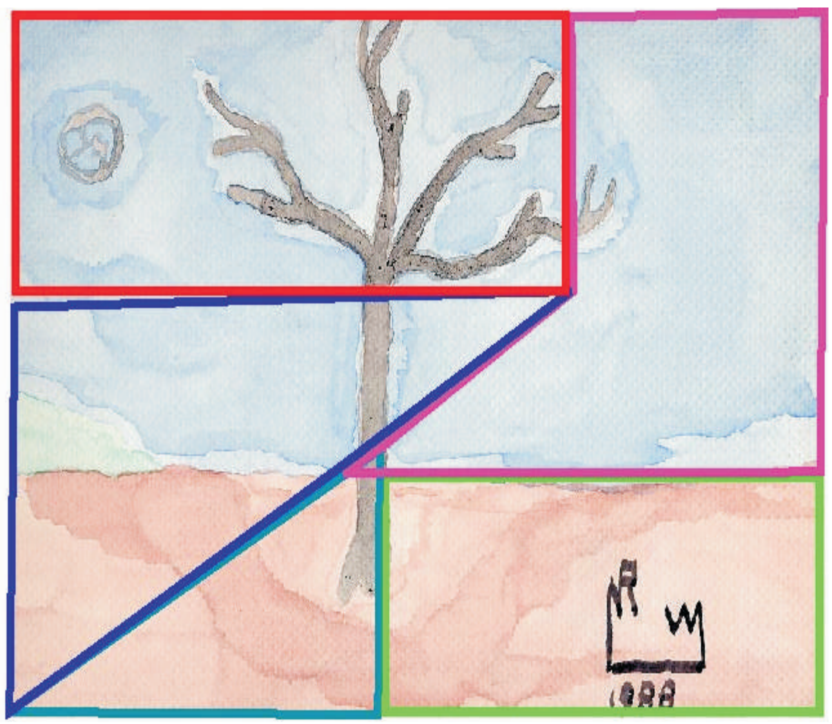

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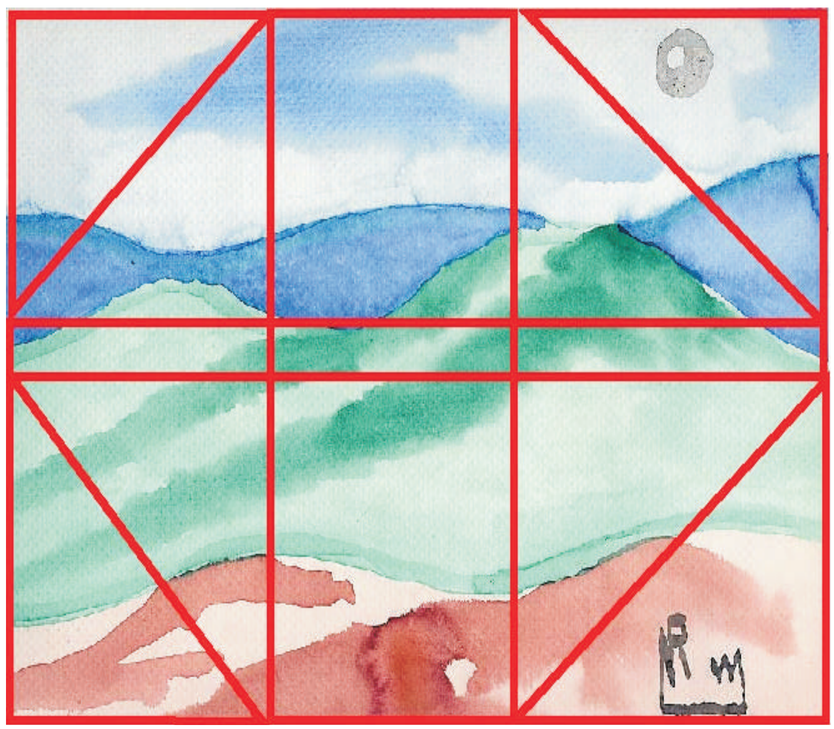

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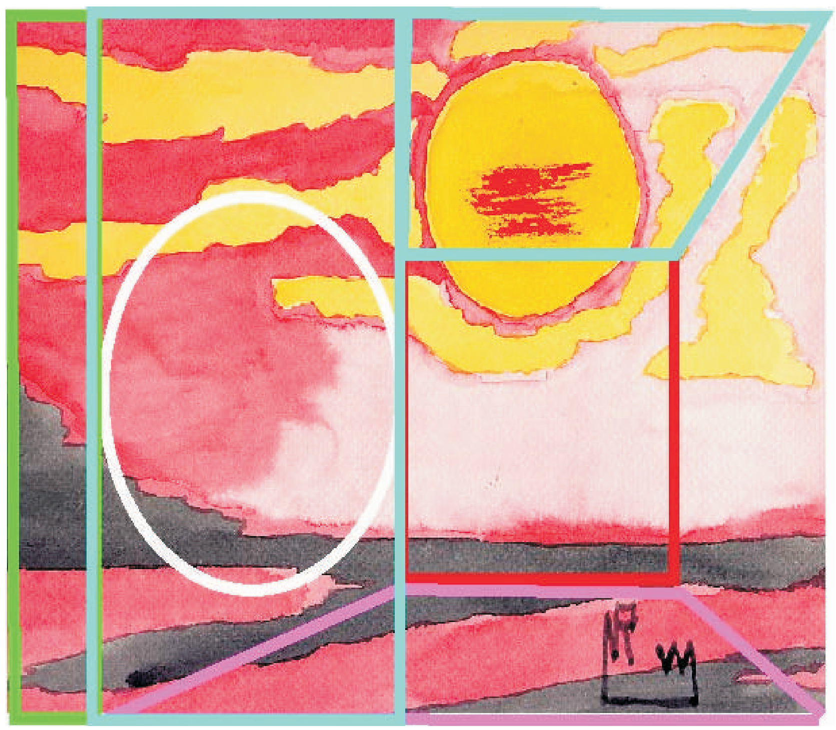

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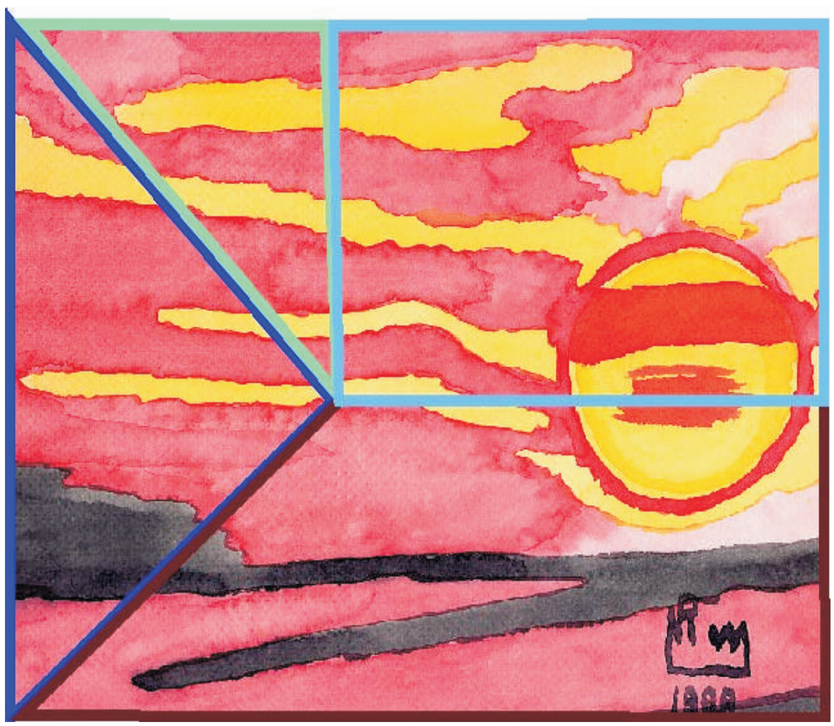

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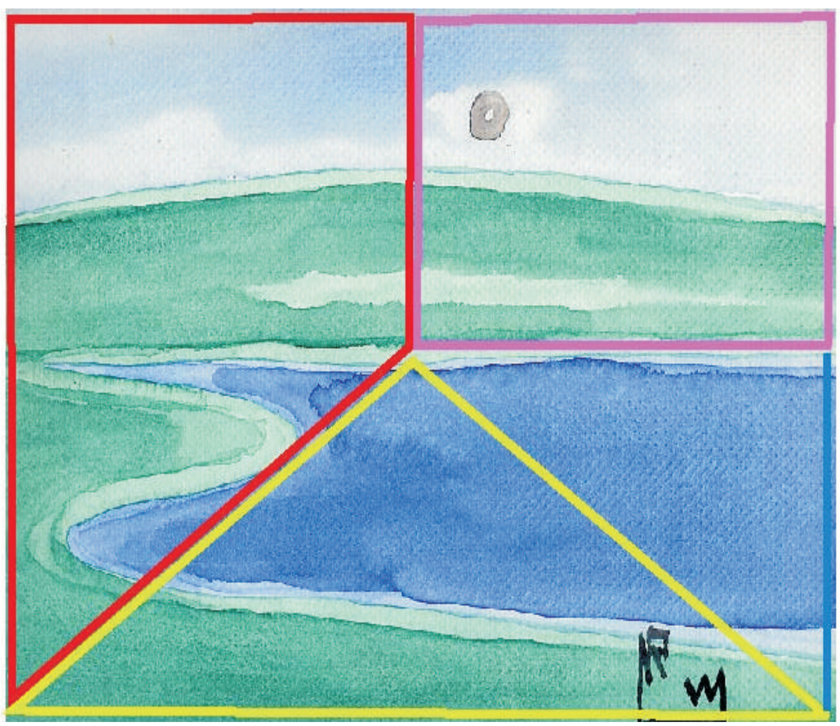

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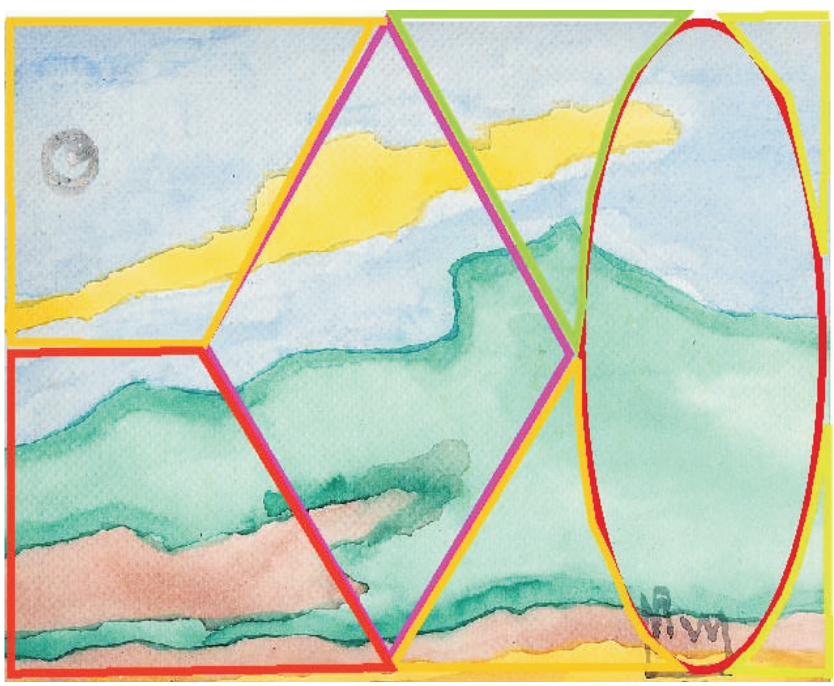

Phase 8

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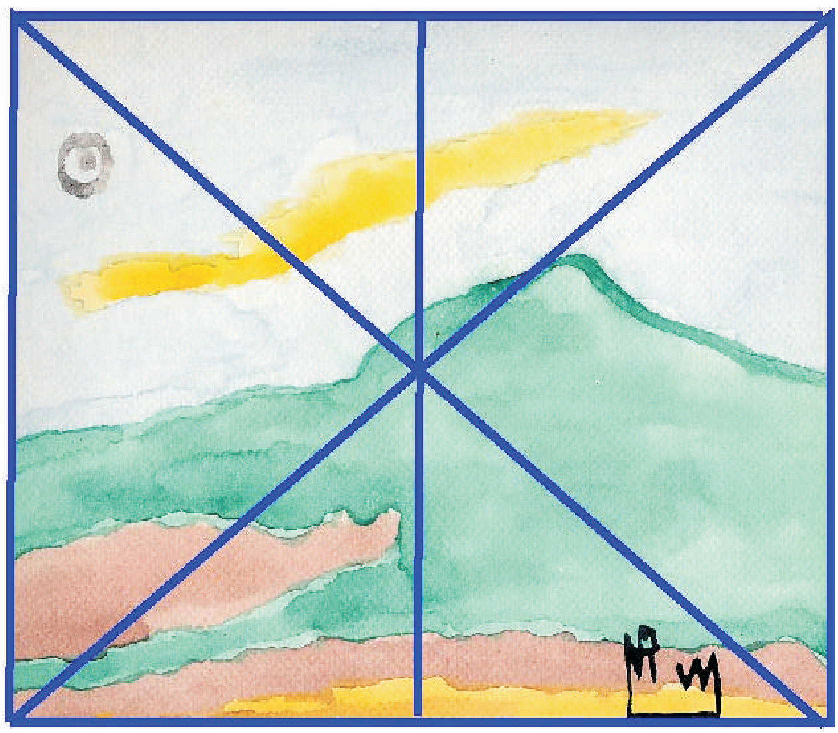


Phase 9

1. THE FORM OF ASKING

The learning can not be given without activity, and an effective way of achieving this activityti is by means of the appropriate and opportune question. To the above-mentioned it is added that when it is to stimulate the creativity and the curiosity, the question appears like an essential and irreplaceable element. They are considered two cases: the teacher's question and the student's question.

1.1 THE TEACHER'S QUESTION.

It has been affirmed repeatedly that the activity is a necessary condition for the knowledge, and that a way to get it, is by means of the use of the question. However, it should be recognized that one of the flaws from the educational it is in fact that he doesn't know how to ask. Many of the questions are, or confused, or without scientific or didactic content. If it wants to improve the methodology in the teaching of the mathematics, it should be subjected to trainings litt le bit longs in which certain abilities and dexterities are developed in the handling of the question, since it is considered that you can not be good teacher f you don't know how to ask. The questions coming from the teacher are classified in three groups: genuine, questions, fictitious questions and clumsy or ridiculous questions.

1.1.1 The genuine question.

It the one that the teacher because: he ignores some aspects related with the topic; he wants to know other focuses; he feels the necessity to learn something new or he wants to compare the concept of his students with his own. It is also said that the genuine question allows that the discente: contribute their own ideas to the development of the course; take trust in the matter when feeling discoverer; and develop his creative capacity, when trying to solve situations that are difficult for the teacher.

Of the previous context it is inferred that the genuine question, is not only advisable didactically but necessary, from the scientific point of view, in the process teaching-learning.

1.1.2 The fictitious question.

It is called fictitious the question that the teacher makes in spite of knowing the answer. This question contains a great didactic value, since by means of it one can:

- Describe the degree of understanding that a student has reached on the topic.
- Create restlessness on the matter.
- Obtain the students' bigger participation in class.
- Stimulate the search sense.
- Detect weak points to reinforce them.
- Introduce new topics.
- Stand out important matters.
- Relate different topics.
- Transmit knowledge (heuristic method).

1.1.3 The clumsy question.

It is called this way the question that should not be made, and much less in class, because it doesn't drive to develop desirable habits in the students, but rather rather it hinders their creative capacity. This question, besides of revealing intellectual poverty in the teacher, it doesn't demand a process of elaboration of the answer from the student. In this question the following categories differ:

- Complement question.
  The number seven is...?
  The number two is... because...?
- Subjective question: is the one where, the only possibility to respond is what the teacher wants in spite of not being totally clear in the context.

What is a triangle?
How can the logarithm of a number be?

- Alternative question. The one of:
  True-false.
- The question that only demands memory.
  Define, enunciate,...
- Obvious question.
- Redundant question.
  According to the principle of redundancy.
- Un-obligatory question.

Did you UNDERSTAND?
As factitive property of the language it is perfectly valid this question, like a way of maintaining the communication, but didactically it is not admitted, and in it defect, other means are recommended so that the teacher finds out if the message was received by the group.

In the teacher's question they are considered two fundamental aspects: THE METHODOLOGY AND THE LEVEL OF DIFFICULTY.

1.1.4 The question methodology.

This expression is used to refer to concrete conditions that affect the quality of the question one way or another. The basic elements that configure the methodology of the question are: THE FLUENCY, THE MOMENT AND THE DYNAMICS. The interpretation is observed of each one of these terms:

THE FLUENCY. It is the personal ability to formulate questions to the group and to solve those that they outline.

THE MOVEMENT. With this term he refers to the student's psychological state and the atmosphere of the class; both aspects can affect the student's answer.

THE DYNAMICS. This consists, basically in distributing the question among all the elements of the group and in taking advantage of the answers (correct and incorrect) to produce new learning's.

To reach certain methodological domain of the question, it is recommended to continue in a gradual and progressive way the following steps:

- To formulate to the group great number of questions and then to indicate in particular who should respond, (this has to do with the moment) with the purpose of that the students have time of thinking.

- To distribute the question in such a way that most of the group participates (dynamics).

- To motivate the students that respond wisely with an approval voice (very well, correct,...) or with a slight comment.

- To avoid verbal and not verbal expressions (faces, actions,...) that can inhibit the students.

The procedure that he has just suggested is necessary but not enough, that is to say, that following the suitable process carefully you can develop certain ability as for the FORM of the question, but not as for the ESSENCE OR CONTENT of it.

1.1.5 The question essence.

The essence or content of the question indicates the degree of elaboration of the answer that should make the speaker, which is to say that the essence of the question is related with its level of difficulty. This, used smartly, contributes to improve the quality of the teaching and therefore to a better development intellectual of the students. The methodology and the level of difficulty (form and essence) configure the quality of the question.

To improve the quality of the question progressively, the following recommendations are made:

- Elaborate verification or EVOCATION questions, with the primordial aim of taking trust for asking. These questions are:

  What?, Who?
  When?, Where?

- Formulate DESCRIPTIVE questions. The exercise with the evocation question provides elements to build others that have a higher level of difficulty. These questions are:
  - How is it made....?
  - Which is the process...?
  - What method is it used for...?

- Build SUPERIOR questions. These they ar e characterized because they demand a bigger elaboration of the answer for the student. The questions of this category are:
  - How is it applied...?
  - How is it used...?
  - Reason...?
  - For what reason...?
  - What is the importance of it...?
  - Which is the central idea...?

The superior questions, are located in different groups according to the objective that is pursued.

- Questions that establish RELATIONSHIPS of identity, difference, similarity, contrast, causes and effect, for example.

- What relationships exist between the potentiation and the radication?
- What similarities can be settled down between the exponential function and the logarithmic one?
- What relationship does it exist between the law of the cosines and the Pythagorean Theorem?
- What likeness are there between the potentiation and the radication?

- Questions that ask to transfer from a symbolic way to another.

Examples:

- Could you express the theorem in your own words?
- Which is the abbreviated form for:

$$\underbrace{x + x + \ldots \ldots + x}_{n \text{ times}}$$

- Can you make an outline that illustrates the Thales theorem?
- What interpretation can one give to the such diagram?

- Questions that require the APPLICATION of concepts or definitions to new situations. Examples:

- Could it be use the Pythagoream Theorem to find the distance among the points A and B?
- How to use a clock to teach the modulate sum?

- Questions that imply the student's INFERENCE. The inference can be of induction or of deduction.

- What can be affirmed of a^2, if "a" is odd?
- If f (x) = $2x^3$ - 3x + 1, calculate f (1).

- Questions that drive to the satisfactory SOLUTION of a problem... Examples:

  - What plan do you suggest for...?
  - What method would you propose for...?
  - Could it be use the indirect method?

- Questions that stimulate the emission of TRIALS OF VALUE. Examples:

  - What do you think of the method suggested fom...?
  - Which is your position regarding...?
  - Who propose something different...?

1.2 THE STUDENT'S QUESTION.

The student has full freedom to ask what he wants, even if his question is seemingly untied to the topic. The profession of the educational not only forces him to espond the questions of the students, but to create the favourable atmosphere so that they are formulated.

However, they can not become public solvers, but rather to take advantage of the queries to motivate the discussion in the group.

1.3 THE ANSWERS OF THE STUDENTS.

The students respond in very different ways to the queries outlined in class, and the educational ones should be prepared to take advantage of to the maximum advantage of the obtained answers.

So important is to formulate correctly the questions that go to the group, as manage the answers of the students knowingly. The most common cases are observed.

1.3.1 The student declares not to KNOW.

In this kind of cases, they should be given suggestions so they stimulate and guide him in the elaboration of the answer. If in spite of the orientations, he insists in his initial attitude, it should be investigated for a possible personal problem.

1.3.2 Monosyllabic answers (yes or no).

In this case it should be requested a justification of the answer, using questions like these ones:

- Why do you think that...?
- Could you use the previous theorem for...?
- Is it possible to relate... with...?
- How would you justify the fact...?

1.3.3 Vague and incomplete answers?

If this is the situation, it is ask to clarity or to given to the educational more information, in this way:

- Who wants to add something?
- Would it be possible to reformulate the answer?
- Could it be better detailed?

1.3.4 INCORRECT answers.

In case of an incorrect answer, the question should be directed again to the group so that the error is detected. The CONVERSATION can begin this way:

- Do you agree with...?
- What is what really is questioned?
- There is some other opinion about...?

1.3.5 SATISFACTORY answers.

In case of a correct the student should be congratulated by saying for example: VERY WELL, EXACTLY, CORRECT,... it is also convenient to use the answer for:

- Emphasize something important.
- Clarify previous concepts.
- Introduce new ideas.
- Restate situations already debated.

1.4 THE HEURISTIC METHOD.

In the development of this study, it has been insisted tacit and explicitly in the importance of the question like didactic element of first order in the work of the educational. One of the most outstanding applications in the question it is the called HEURISTIC or EURETIC method.

The HEURISTIC word is derived of the Greek EURISKEIN that means to FIND. In this sense, the Heuristic can be understood as a method or procedure by means of which one can DEDUCE OR to INDUCE the truth. This study won't be in charge of of the study of the heuristic as such, but of its application in the solution of mathematical problems.*

From the point of view of the didactics, the heuristic method, consists basically on to outline a problem to the student and to help him to find the correct solution, by means of the reiterated use of the question.

** Who wants to observe serious studies on the construction of the Heuristic, it can consult the works of Descartes, Leibnitz, Pappus and Bolzano.*

In the solution of a problem with the heuristic method, the following steps or stages are pointed out:

STAGES OF THE HEURISTIC METHOD.

- Understand the problem.
- Identify the data and the incognito ones.
- Illustrate the enunciated by means of an scheme.
- Devise a plan and execute it.
- Analyze the obtained solution.

Example 1: To find the value of the diagonal of a square in function of the side.

What is what really requests the problem?
Can you repeat the sentence?
Are there terms that you ignore?
What does it means FUNCTION in this case?
Which are the data of the problem?
Which is the incognito?
Can one make an scheme that illustrates the problem?
Can you use letters to represent the data and the incognito?
What principle it is applied to find the value of x?
Can you apply the Pythagorean Theorem?

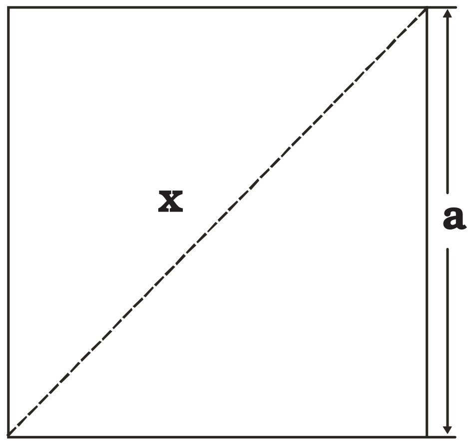


Figure 1.1

Now that there is a plan, it is executed to obtain the solution.

$$x^2 = a^2 + a^2$$
$$\therefore x^2 = 2a^2$$
$$\therefore x = a\sqrt{2}$$

What does the answer suggest?
How much does it measure the diagonal of a square whose side is of 6 cms. longitude?
How to find the value of the side in function of the diagonal?
Can it be made a simlar problem to the previous one?

By means of a retrospective look to the development of the problem, one can observe clearly the different stages of the heuristic method.

Example 2: Find the measure of the diagonal of a cube in function of the edge.

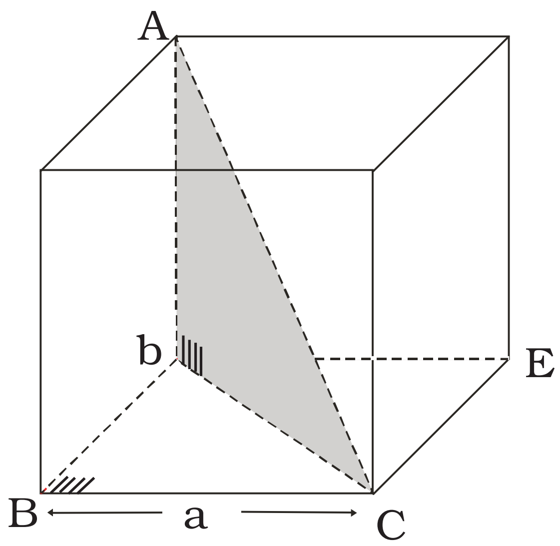


Figure 1.2

What objects do they have the form of a cube?
Can this room be compared with a cube?

Can it be made a figure that illustrates the problem?
Can all the data be represented in the figure?
s it correct to assign to each edge the value of "a"?
Who does suggest a plan to solve the problem?
Can it be trace the diagonal ($\overline{AC}$) of the cube?
How to use the diagonal ($\overline{DC}$) of the base?
How is the triangle BDC?
How to find the value of ($\overline{DC}$) in function of the edge?
How can be applied the Pythagorean Theorem on the ADC triangle?
How does the ADC triangle look like?
What does the incognto represent in the ADC triangle?
What theorem can be applied to the ADC triangle?

At this time the group has clear idea of the pocess that should be continued to find the incognto, therefore it should be alowed to the students to carry out the plan that it has just built.

$$\overline{DC}^2 = a^2 + a^2$$
$$\therefore \overline{DC} = a\sqrt{2}$$
$$\overline{AC}^2 = a^2 + DC^2$$
$$\overline{AC}^2 = a^2 + (a\sqrt{2})^2$$
$$\therefore \overline{AC} = a\sqrt{3}$$

What comparisons can it settle down among the two previous problems?
How to find the side of a cube in function of the diagonal?
Which is the value of the diagonal of a rectangular parallelepided in function of its edges?
Which is the volume of a cube whose diagonal 10 cms?

PROSPECTIVE:
For studies in the future it will be meditated on the question in the paradigms and methodologies in scientific research.

2. THE CULTURAL INHERITANCE

As well as the art works are conserved in the fields of the painting, the music, the sculpture, etc., likewise it should be conserved and to be made know the wonderful work of the mathematics. In the construction of the monument of the mathematics it has been invested a lot of energy and it is not fair that it gets lost.

Some of the works that constitute for themselves a cultural monument in the field of the mathematics are the following ones:

Pythagorean Theorem.
Newton's binomial.
The Pascal's Triangle.
The Zeno's Paradoxes.
The number.

2.1 THE ZENO'S PARADOXES (400 before the Common Era).

The school from Elea was a philosophical sect founded by Parmenides. Zeno, who belonged to this school, it as one of the many enemies that the Pythagorean had. Zeno formulated the following antinomies to bother the mathematicians.

2.1.1 The Antinomy between the continuity and the possibility of subdivision until the infinite.

Here Zeno tried to show the difficulties of admitting an absolute beginning, a first unit, an indivisible elementary particle.

"All unit worthy of its name should be indivible, besides an indivisible thing won't also be able to have dimension if it's not divisible, then the unit from the moment in that it doesn't have dimension it's confused with the nothing, let us add so many "nothings" like we want and the result will be anything, then there is no multiplicity. Now, if the multiplicity exists, its parts are far away one from another, in the interval of them can be inserted other ones, this operation can be repeated infinite times, then all unit is infinitely big, therefore there are no units neither multiplicity nor both they are infinite."

The importance of this paradox resides in that it teaches that the continuity is something that should be included, such it is the case of the LINES, the SURFACE, etc. as long as the number and the numeation systems are product of the fellow's operative composition, in which plays an important part the rational activity. Naturally, the intuitive thing and the rational things should be combining in the most diverse proportions in the solution of any mathematical problem.

It should also be kept in mind that in all phenomenons, in each instant and in al the places, the unit and the fight of contrary exists. It is also remembered that the particular thing exists in the general thing and the general in the particular.

2.1.2 The Antinomy between rest and movement.
Before the arrow gives in the target it should travel half of the distance, then the half of the half and soon. As these distances they have real dimensions: 1/2, 1/4, 1/8... of total longitude of the road, then the longitude of the trajectory is the sum of an infinitely big number of straight line segments that although being more and more small always has a real dimension; and the arrow to travel an infinite quantity of spaces it will need an infinite time. The arrow doesn't have another resource that to remain in its point, in contact or stick to the rope of the arch.

It smell a rat, there's something fishy here; show it.
The students will analyze the paradox for the next class...
Now it will be described a little on <u>mythology.</u>

In the Greek mythology it is counted that Thetis had seven children, that she put to the fire with the purpose of making them immortal. All died except one. ACHILLES who was invulnerable. It's a pity that the fire didn't play him in the tendon of the heels where his mother held him with the fingers. When Achilles grew, he ended up being the most valiant, strong and speedy in Agamemnon's armada whose brother MENELAO it was off ended by PARIS, stealing to its HELLENIC wife. There were the TROYA war begins.

Zeno of Elea who lived a hundred years after Achilles, devised the following problem was devised to tease the mathematicians of the time: if it is carried out a competition between Achilles and a turtle, with the only condition that the turtle has some advantage, Achilles will never be able to reach her, because while he travels the distance that separates him of the turtle, the turtle advances a certain distance and so on. This problem is known with the name of ZENO'S PARADOXES.

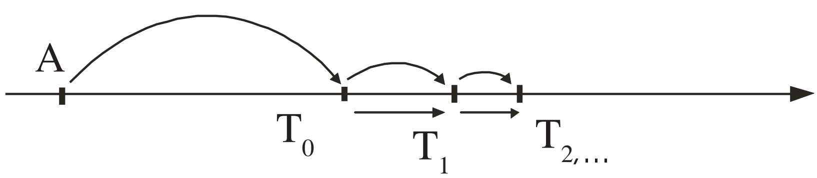


Figure 2-1

Will Achilles reach the turtle?
- Yes: Where is the error, if this error exists?
- No: How it is able to a car to pass another in a freeway?.

What relationship does it exist between this paradox and the antinomy between rest and movement?

Can it be prove the statement of Zeno? Can it be refute?

If it is really wanted to find an explanation to the paradox, it is necessary to investigate, it is considered a peculiar case of the problem, to verify if Achilles reaches or not the turtle. Then the problem will be studied in a general way.

It is supposed that Achilles runs at least quicker 10 times that a turtle. If Achilles grants a distance of 100 meters to a turtle, this won't be able to never be reached by him.

TRAVELED DISTANCES	
While Achilles it travels	The turtle travels
100 m	10m
10 m	1 m
1m	1 dm
1 dm	1 cm
1cm	1 mm
“	“
“	“
“	“

Figure 2-2

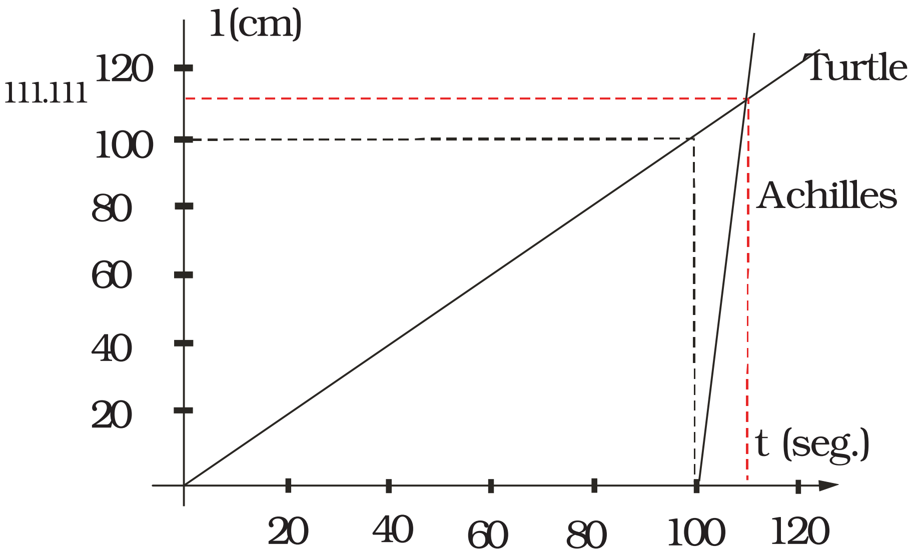


Figure 2-3

Be V = 1 m/seg: (Speed of the turtle)
:. V = 10 m/seg: (Speed of Achilles)
d = Distance traveled by the turtle since the moment that Achilles leaves, until it is surpassed by him.

d = 10+1+0.1+0.01+0.001...
:. d = 11.111.....= 11.1
:. d = 11.1; (1/10) =0.1; (2/10)=0.2

Also: 0,111... = 0,1 = (1/9)

Then the total distance traveled by the turtle until the moment of being surpassed by Achilles is:
d = 0,1 = (1/9) meters and nothing else.

What could be a mystery in another time, today it is solved easily today thanks to the numeric language. In spite of being such a simple pbblem, was necessary to wait several centuries so that Achilles REACHED the turtle.

> "Achilles could not reach the turtle until the time of the Cartesian Geometry that gave space at the time". LANCELOT.

2.1.3 General study of the paradox.

The problem of the turtle that can not be surpassed by Achilles, is the same problem of the arrow that can not take off from the arch. Zeno says: "Before the arrow gives in the target it has to travel half of the distance, then half of the half…". Let's represent these data in a diagram.

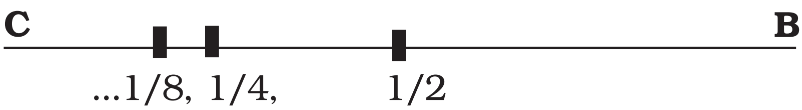


Figure 2-4

The numbers of the figure can be written in this way:
1/2, 1/4, 1/8, 1/16,...?

This expression it is called INFINITE SUCCESSION. It is to fill the target.

It is written the succession again:
$1/2, 1/2^2, 1/2^3, \ldots, 1/2^n$ (1)

Each one should write several finite and infinite successions and try to add their terms.

In the succession (1) "!", it is changed to "+"
$1/2 + 1/2^2 + 1/2^3 + \ldots + 1/2^n$ (1)

This new expression takes the name of series.
A series doesn't represent a number, but THE DESIRE of adding an infinite number of terms. How to add all the

terms of a series? It is easy to add the first terms, but how to add them all?. It is necessary to make this sum to be able to know the meaning of the paradox.

The series is taken:
$1/2+ 1/2^2+ 1/2^3+...+ 1/2^n = 1/2^n = 1/2+1/2. (1/2) +1/2. (1/4)+1/2.(1/8)+...+1/2.(1/2^{n-1})$ (2)

This type of series, in the one which a term anyone can be obtained multiplying the precedent for a fixed number (REASON) it is called GEOMETRIC SERIES. Why?

It is called:

a: To the first term of the progression.

q: The reason.

The expression (2) can be written this way:

$a+aq+aq^2+aq^3+...+aq^{n-1}$, in the one were:

The second term: $aq=\sqrt{a.aq^2}$

The third term: $aq^2= \sqrt{aq.aq^3}$

.

.

$ai = \sqrt{ai -1 , ai +1}$

So that the name of GEOMETRIC PROGRESSION, is due to that each term is the GEOMETRIC MEAN among which proceeds and the one that it continues in the series. To be able to add the terms of a geometric progression we should appeal to the concept of MATHEMATICAL INDUCTION.

By means of the mathematical induction it can be proven that:

$$a+aq+aq^2+...+aq^{n-1} = \left(\frac{a (q^n-1)}{q - 1}\right) \quad (Pn)$$

For n = 1; a = a (q-1/q-1) = a
For n = 2; $a+aq=a(q^2-1/(q-1))=a(q+1)$

It is supposed that the proposition (P_n) it is completed for n=k, and to prove that n is completed n= k+1

For n=k
$a+aq+aq^2+...+q=a^k(q-1/q^k-1)$ (Inductive hypothesis)
:. $a+aq+aq^2+...+aq^{k-1}+aq^k=a(q^k-1/q-1)$
$$+\ aq^k = \left(\frac{a(q^k - 1 + q^k(q-1)}{q-1}\right)$$
$$= a\left(\frac{(q^{k-1}-1)}{q-1}\right)$$

Then: $a+aq+aq^2+...+aq^{n-1}= a\left(\frac{(q^n-1)}{q-1}\right)$

In the geometric progression that was of the paradox has: $q=1/2 < 1$

The students should make an analysis of the formula $\frac{a(q^n-1)}{q-1}$ for some values peculiar values of q.
They should reach conclusions like this one:
To suppose that q < 1; for comfort it is taken

q = 0,1

If q = 0,1 ; $q^n = \left(\frac{1}{10}\right)^n$

:. $q^n \rightarrow 0$

If $q^n \rightarrow 0$; $a\left(\frac{(q^n-1)}{q-1}\right) = \frac{a(0-1)}{q-1} = \left(\frac{a}{1-q}\right)$

Therefore, for q=1/2 we have:
$$1/2+1/2.(1/2)+1/2(1/4)+...+1/2\ (1/2^{n-1}) = \left(\frac{1/2}{1-½}\right) = 1$$

Isn't this a surprising answer? It was not expected that the sum of an infinite number of terms gave a very big number! However only the UNIT was obtained. Can it be explained the reason of this? When the sum of an infinite number of terms is a fixed number, the series it is called CONVERGENT SERIES.

It is expected that the students reach conclusions like this one: The sum of the terms of this series is only ONE, because the value of the terms decrease very quickly, while the total increase very slowly.

> To REMEMBER
> Which is the explanation of the paradox?
> What teachings can be extracted of it?
> What about this statement: The human mind doesn't accept in a natural way the concept of CONVERGENCE.

When we enunciate the antinomy between rest and movement we said that we would study something about the GREEK MYTHOLOGY, but it was a trick, because in fact it was wanted to give one more example of HOW TO TEACH THE MATHEMATICS.

2.1.4 Derivations of the paradox

2.1.4.1 Evaluation of some decimals:

The general expression of the geometric progressions can be used to evaluate periodic decimals

Example: Evaluate the decimal: 0,1616...

$$a+aq+aq^2+\ldots+aq^{n-1}=\frac{a\,(q^n-1)}{q-1}$$

$$0.1616... = \frac{16}{100} + \frac{16}{10000} + \frac{16}{1000000} + ...$$

$$= \frac{16}{100} + \frac{16}{100} \frac{(1)}{100} + \frac{16}{100}\left(\frac{(1)}{100}\right)^2 + \frac{16}{100}\left(\frac{(1)}{100}\right)^3 + ...$$

$$= \frac{16}{100}\left[\frac{(1/100)^n - 1}{1/100 - 1}\right]$$

$$= \frac{16}{100}\left[\frac{0 - 1}{-(99/100)}\right]$$

$$= \frac{16}{99}$$

Exercises: Find fractions that generate the following decimals

a. 2,702702...
b. 98,198198...
c. 1,73131...
d. 0,42165165...

2.1.4.2 Other types of series:

It has been said that the series: $a+aq+aq^2+...+aq^{n-1}$ it is convergent for $q < 1$. What happens for $q \geq 1$

Let us suppose that $q=1,5$

$\therefore q^n=(3/2)^n=3^n/2^n$

Here you can see that if "n" is very big, then the sum "Sn" it is also very big; in cases like this is told that the series is DIVERGENT. In general terms, a series is DIVERGENT if the sum of its terms is not a fixed number.

Sometimes it is simple to determine the convergence for simple grouping.

Be: $S_n = 1 + 1/2 + 1/3 + 1/4 + \ldots + 1/n$

$\therefore$ $S_n = (1+1/2) + (1/3+1/4) + (1/5+1/6+1/7+1/8)+\ldots+ (1/2^{n-1}+ 1 + 1/2^{n})$

Be: $S'_n = (1/2 + 1/2) + (1/4 + 1/4) + (1/8 + 1/8 + 1/8 + 1/8) + \ldots +$

$\therefore$ $S'_n = 1 + 1/2 + 1/2 +\ldots$

It is easy to see that S'n grows quickly. As Sn> S'n then, "Sn" is DIVERGENT. This is an elementary example of the condition of CAUCHY.

To consult and to discuss

If $-1 < q < 1$: The series is convergent.
If $q \geq 1$: The series is divergent.
If $q \leqslant -1$: The series is oscillating.

2.2 ANECDOTE OF GAUSS.

Before relating the anecdote, it is asked to the students to write in the more simplified way as possible the next expression:

$$1/2 + 1/2^2 + \ldots + 1/2^n$$

...The professor had the habit of assigning to the students boring works. One day the teacher said to his students: TODAY YOU WILL HAVE TO SUM THE INTEGERS FROM 1 TO 200. Two or three minutes later, GAUSS who was one of his students showed professor BUTTNER the correct answer. HOW COULD HE DO IT SO FAST? the teacher said. Let us think how he made it so quick; that is to say, how to add the integers from 1 to 200 in less than three minutes; he thought that that work was very tedious and he only wrote some of them.

1	+	2	+	3	+	…	+	200
200	+	199	+	198	+	…	+	1
201	+	201	+	201	+	…	+	201

It is very easy to add 200 of the same addends; until multiplying: 200 x 201. To arrive to the answer just divide the product in 2, since they have taken the adding twice.

$$\therefore\ 1+2+3+\ldots+200 = \frac{200 \times 201}{2} = 20100$$

To express the sum of many terms when these follow a general law of formation the symbol it is used "$\sum$" (Summation)

Example:

$$1 + 2^2 + 3^2 + 4^2 + 5^2 = \sum_{i=1}^{5} {}^2$$

$$1 + 9 + 25 + 49 = \sum_{i=1}^{4} (2i-1)^2$$

1 + 2 + 3 + … + 200= ?

$$0+4+16+36+\ldots+?= ?\ \sum_{i=1}^{n} (2i-2)^2$$

$$1+1+9+25+\ldots+?=?\ \sum_{i=1}^{n} (2i-3)^2$$

$$\sum_{i=1}^{n} \frac{1}{1\,(4i-1)^2} = ?$$

$$\sum_{i=1}^{n} \frac{1}{2i-1} = ?$$

$$x + \frac{x^5}{5!} + \frac{x^9}{9!} + \ldots + ? = ? \quad \sum_{i=}^{n} \frac{x^{4i+1}}{1(4i+1)!}$$

$$1 + \frac{2^3}{2!} + \frac{3^3}{3!} + \frac{4^3}{4!} + \ldots + ? = ? \quad \sum_{i=1}^{n} \frac{i^3}{i!}$$

1/1 . 2.3. + (1/3).(5).(7). + (1/5).(7).(9) +...+ ? = ?

$$\sum_{i=1}^{n} \frac{1}{(2i+1)(2i+3)(2i+5)}$$

2.3 THE PASCAL'S TRIANGLE.

2.3.1 Considerations.

BLAISE PASCAL. It was a physique, mathematician, philosopher and French writer. Since a little boy he was interested in the mathematics. To the 18 years of age he invented the first calculating machine that one knows. Soon after the correspondence that sustained with PIERRE FERRAT to near games of chance he began in the study of the probabilities. He demonstrated that the atmospheric pressure falls when the height increases. The presses and the current hydraulic jack are based on the principle that takes his name.

PASCAL devised a triangular arrangement of numbers that is known as PASCAL'S TRIANGLE, although some attribute it to the ITALIAN mathematician TARTAGLIA.

LEVEL ZERO------------------1------------------LINE: 1
LEVEL ONE---------------1-------1---------------LINE: 2
LEVEL TWO-------1--------2----------1-------------.

1---------3-----------3---------1
1------4-------------6-----------4---- -------1
1----5---------10---------10----------5----------1
1----6------15---------20----------15--------6---------1

Figure 2-5

In this triangular arrangement it is observed that a correspondence exists among the numbers that you/they appear in each line and the coefficients that are obtained in the development of the NEWTON'S BINOMIAL: this way:

LEVEL ZERO: $(a+b)^0 =$ 1......Element of the line 1
LEVEL ONE: $(a+b)^1 =$ 1.a+1.b...Element of the line 2
LEVEL TWO: $(a+b)^2 =$ $1.a^2+2a.b+1.b^2$. Element of the line 3

To THINK:
How to find a law of formation of the lines in the triangular arrangement?
Choose horizontal or oblique lines and to find their formation law.
Does it make sense speak of symmetries in this triangle?
Use the triangle to obtain the number of subsets of a group.
How topical they can be explained with the triangle of Pascal?

2.3.2 Applications of the Pascal's Triangle.
The triangle of Pascal has multiple applications among which stand out the following ones:

- Introduce or execute the concept of coordinated.
- Find the dividers of a number.
- Find the minimum common mutiple of several numbers.
- Determine the probability of an event (face and stamp)...

2.3.2.1 Coordinates of the Cartesian Plane.

- Each student or team has an outine like the one that is shown in the figure 2-6

- Any two circles are chosen any and they are assigned a letter to each one.

- It is requested to the students to choose a ROAD to pass from one point to another, in the sense of the arrows.

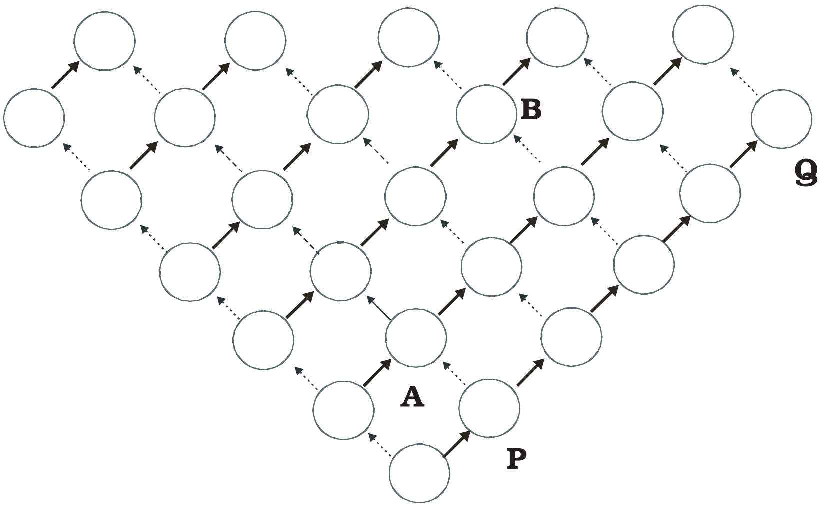


Figure 2-6

- The students count the number of arrows separately traveling toward the right and toward the left.

- It is observed that the result is the same one in any elected road.

  They are written inside a parenthesis separated by a comma, the numbers that represent the arrows toward the right and toward the left.
  (IN THAT ORDER).

Example:
From A to B----- (3,1); (two roads)

Arrows toward the left
Arrows toward the right.

From P to Q------(4,0); a single road.

- The student identifies the numbers of the parenthesis like the ORDERLY COUPLE corresponding to the coordinates of a point of the plane. Regarding the previous work one can score:
- The coordinates of a point are given with relationship to another point.
- It is supposed that the coordinates of the starting point are (0,0).

2.3.2.2 Dividing of a Number.
Each student has an outline like the one that is shown in the figure 2-7 (circles in white). The students should write a number in each section according to the following rules:

- You begin with the number ONE (1).
- All movement of a circle to the following one implies a multiplication; for 2 toward the left and for 3 toward the right. (This condition can andti should be varied).
- Once full the circles, one of them is chosen, for example the (4,2). The students should enunciate all the numbers that they find leaving of (1) until arriving to the elected point.

Example:
To arrive to the point (4,2), there are:
1,3,9,27,81,162,324.
1,2,4,12,36,108,324.
1,3,6,18,54,108,324.

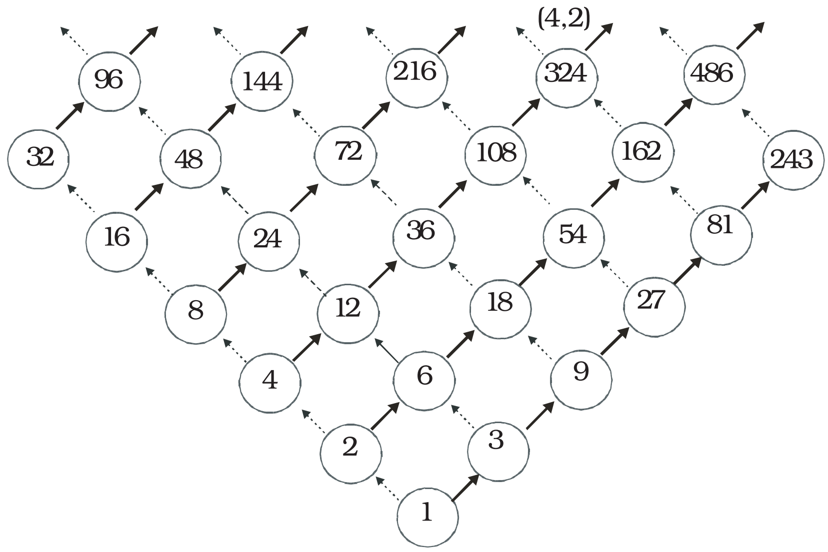


Figure 2-7

- It is made notice that all these numbers are dividing of 324.

As complement to the previous work it can:

- Propose the previous process for other numbers, such as: 7 and 5.
- Apply the same idea to find MULTIPLES OF A NUMBER. And the minimum common multiple of two numbers.
- Analyze the group of dividing of a number.

2.3.2.3 Probabilities of the type face and stamp.
It is to determine the probabilit y that when throwing "n" currencies to the air; "s" currencies fall STAMP and "n"-"s" fall FACE, for the analysis you proceeds this way:

The group is divided in teams and to each team she/ he is given an outline like the one that is shown in the figure 2-8.

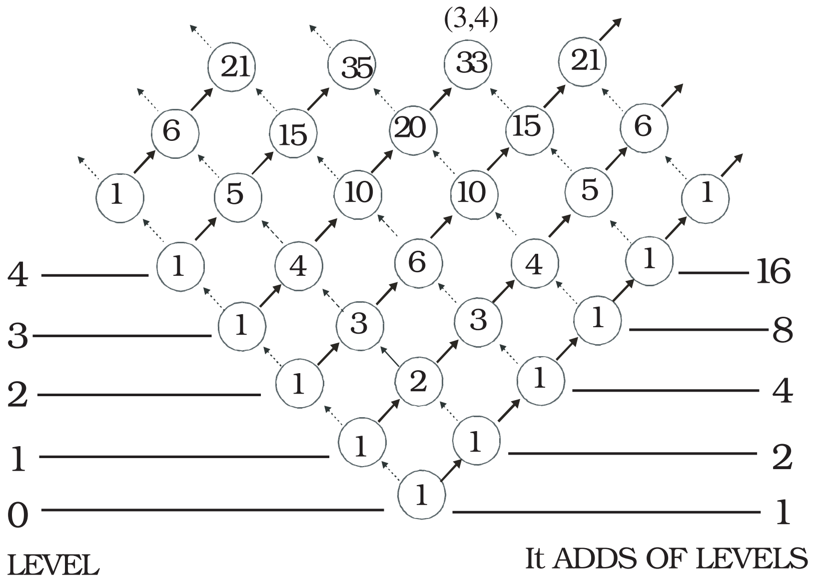


Figure 2-8

- THE NUMBER corresponding to the LEVEL, indicates the number of currencies that are thrown in the air. (No. of the level =n).

- It is taken as the reference point the (1) whose level is ZERO.

- For the point P (a, b); "a = s", is the number of arrows traveled from (1) toward the left (NUMBER OF STAMPS); "b" is the number of arrows journey toward the right. (NUMBER OF FACES).

- It is suited in calling:

h = Number that is in the circle of coordinated, (a,b)
k = Sum of the corresponding levels to the "n" level.
n = Number of the level = number of the thrown currencies.

Examples:
For the point of coordinated (3,4), it has:

a = 3
b = 4
n = 7
h = 35
k = 128

Then the probabilit y that when throwing 7 currencies to the air; 3 falls stamp and 4 falls face is:

$$(h/k) = (35/128)$$

Likewise, the probability that when throwing 5 currencies, 2 fall stamp and 3 face is of 10/32

2.4 NEWTON'S BINOMIAL.

2.4.1 Previous considerations.

The following equalities are presented here in the WAY OF DEFINITIONS, but they can be pr oven in a combinatorial analysis.

$$n! = 1 \times 2 \times 3 \times \ldots \times n = \text{F actorial of "n"}$$

$$\binom{n}{k} = \frac{n!}{k!\,(n-k)!}; \quad n > 0, \; 0 \leqslant k \leqslant n$$

$$0! = 1$$

Applying these definitions to particular cases we have:

$$\binom{0}{0} = \frac{0!}{0!}(0-0)! = \left(\frac{1}{1 \times 1}\right) = 1$$

$$\binom{1}{0} = \frac{1!}{0!}(1-0)\,! = \left(\frac{1}{1 \times 1}\right) = 1$$

$$\binom{1}{1} = \frac{1!}{0!}(1-1)! = \left(\frac{1}{1 \times 1}\right) = 1$$

Comparing these results with the elements of the Pascal's triangle, it can be conclude the following conformation of the triangle.

$$\binom{0}{0}$$
$$\binom{1}{0} \quad \binom{1}{1}$$
$$\binom{2}{0} \quad \binom{2}{1} \quad \binom{2}{2}$$
$$\binom{3}{0} \quad \binom{3}{1} \quad \binom{3}{2} \quad \binom{3}{3}$$
$$\binom{4}{0} \quad \binom{4}{1} \quad \binom{4}{2} \quad \binom{4}{3} \quad \binom{4}{4}$$
$$\binom{5}{0} \quad \binom{5}{1} \quad \binom{5}{2} \quad \binom{5}{3} \quad \binom{5}{4} \quad \binom{5}{5}$$

Figure 2-9

Each one of these combinatorial numbers is associated with the geometric figure, this way: it is called SIMPLISM to the simplest figure that can be obtained in the space of "n" dimensions and some particular cases are observed.

In the space of ZERO dimension (R^o), the simple one is the POINT.

$$\binom{0}{0} = \binom{1}{0} = \binom{1}{1} = 1$$

In the dimension space ONE (R), the simple one is the SEGMENT OF STRAIGHT LINE.

$$\binom{2}{1} = 2$$

In the space of dimension TWO (R^2), the is the triangle.

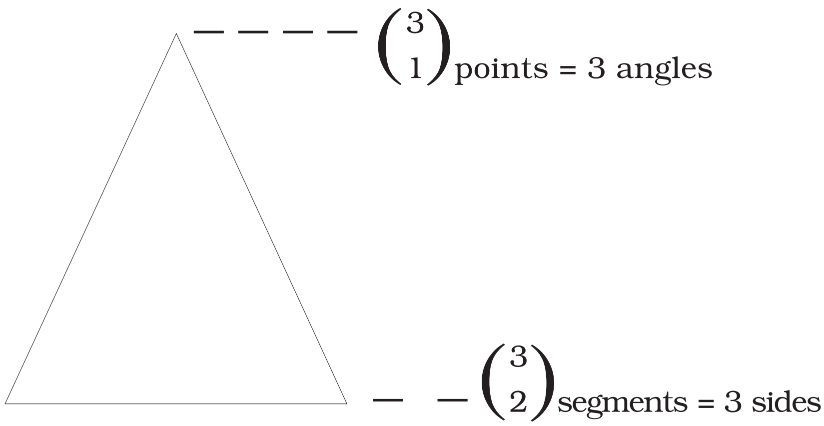


Figure 2-10

In the space of dimension THREE (R^3), the simple one is formed by 4 points non coplanar. This figure it is defined this way:

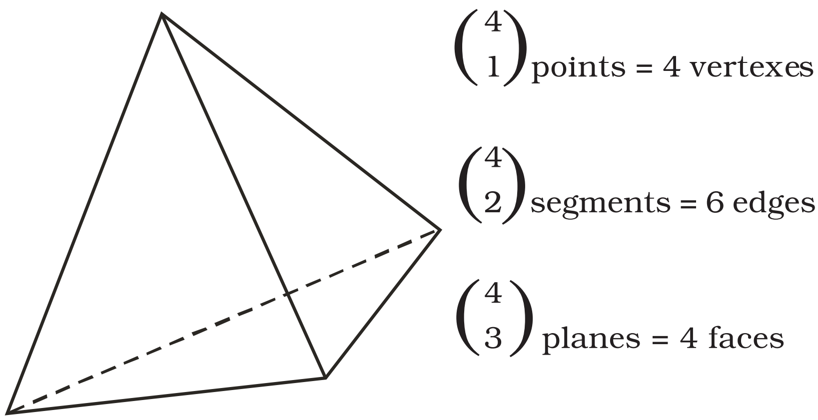
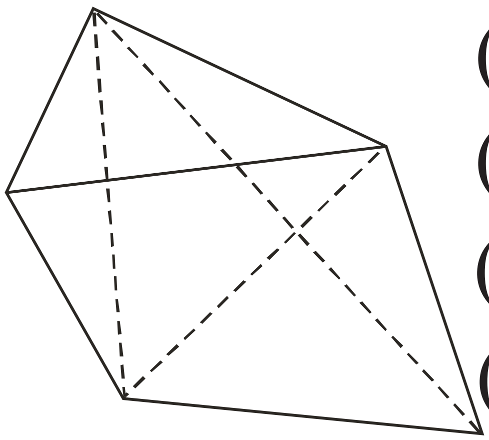


Figure 2-11

In the space of dimension FOUR (R^4), the simple one is defined this way:



$\binom{5}{1}$ points = 5 vertexes

$\binom{5}{2}$ segments= 10 edges

$\binom{5}{3}$ planes = 10 faces

$\binom{5}{4}$ Small cosmos = 5 solids

Figure 2-12

In the space of "n" dimensions, the simple one it is defined for:

$$\binom{n+1}{1}, \binom{n+1}{2}, \binom{n+1}{3} \ldots \binom{n+1}{n}$$

2.4.2 Binomial Applications.

2.4.2.1 Prove that: $\binom{n}{k} + \binom{n}{k+1} = \binom{n+1}{k+1}$

Suggestion 1: Reduce both members to a third expression.

Something like this is expected:

$$\binom{n}{k} + \binom{n}{k+1} = \frac{n!}{k!\,(n-k)!} + \frac{n!}{(k+1)!\,(n-k-1)!} \quad (1)$$

$$\binom{n+1}{k+1} = \frac{(n+1)\,!}{(k+1)!\,(n+1-k-1)!} = \frac{(n+1)!}{(k+1)\,!\,(n-k)!} \quad (2)$$

Suggestion 2: Starting from (1) get to (2)

$$(1) \therefore \frac{n!\,(k+1)}{k!\,(n-k)\,!\,(k+1)} + \frac{n!\,(n-k)}{(k+1)\,!\,(n-k-1)\,!\,(n-k)}$$

$$= \frac{n!\,(k+1)}{(k+1)!\,(n-k)\,!} + \frac{n!\,(n-k)}{(k+1)\,!\,(n-k)\,!}$$

$$= n!\left(\frac{k + 1 + n - k}{(k+1)\,!\,(n-k)\,!}\right)$$

$$= \left[\frac{(n+1)\,!}{(k+1)\,!\,(n-k)} = 2\right]$$

$$\therefore \binom{n}{k} + \binom{n}{k+1} = \binom{n+1}{k+1}$$

2.4.2.2 Let's prove that:

$$\sum_{k=0}^{n} \binom{n}{k} = 2^{n}$$

2.4.2.2.1 Let's prove that:

For n = 0: $\binom{0}{0} = 1 - 2^{o}$

For n = 1: $\binom{1}{0} + \binom{1}{1} = 2^{1}$

For n = 2: $\binom{2}{0} + \binom{2}{1} + \binom{2}{2} = 1+2+1 = 2^{2}$

2.4.2.2.2 It is to prove that:

$$\binom{n}{0} + \binom{n}{1} + \ldots + \binom{n}{n} = 2^{n}$$

Suppose that Pn is fulfilled for n=x and prove that it is fulfilled for n= k + 1

(H): $\binom{k}{0} + \binom{k}{1} + \ldots + \binom{k}{k} = 2^k$

(T): $\binom{k+1}{0} + \binom{k+1}{1} + \ldots + \binom{k+1}{k+1} = 2^{k+1}$ (1)

$$\binom{k}{0} + \binom{k}{0} + \binom{k}{1} + \binom{k}{1} + \binom{k}{2} + \binom{k}{k}$$

$\therefore$ (1)= $\binom{k}{0} + \left[\binom{k}{0} + \binom{k}{1}\right] + \left[\binom{k}{1} + \binom{k}{2}\right] + \left[\binom{k}{2} + \binom{k}{3}\right] + \ldots \binom{k}{k}$

$= 2\left[\binom{k}{0} + \binom{k}{1} + \binom{k}{2} + \ldots + \binom{k}{k}\right]$

$= 2 \cdot 2^k$

$= 2^{k+1}$

2.4.3 Binomial's development.

Prove that: $(a+b)^n = \binom{n}{0} a^n b^o + \binom{n}{1} a^{n-1} b^1$

$+ \ldots + \binom{n}{n} a^o b^n$

For n = 1 : $(a+b)^1 = \binom{1}{0} a^1 b^o + \binom{1}{1}$

$a^o b1 = a + b$

For n = 2: $(a+b)^2 = \binom{2}{0} a^2 b^o + \binom{2}{1}$

$a^1 b^1 + \binom{2}{2} a^o b^2$

$= a^2 + 2ab + b^2$

Let us suppose that Pn is true for n=k and let us prove that it is fulfilled for n=k + 1

(H): $(a+b)^k = \binom{k}{0} a^k b^o + \binom{k}{1} a^{k-1}b^1 + \dots + \binom{k}{k} a^o b^k$

Also:

$(a+b)^{k+1} = (a+b)^k (a+b)$

$= \left[\binom{k}{0} a^k b^o + \binom{k}{1} a^{k-1}b^1 + \dots + \binom{k}{k} a^o b^k\right](a+b)$

$= \binom{k}{0} a^{k+1}b^o + \binom{k}{1} a^k b^1 + \dots + \binom{k}{0} a^k b^1 + \binom{k}{1} a^{k-1}b^2 + \dots + \binom{k}{k} a^o b^{k+1}$

$= \binom{k}{0} a^{k+1} + \left[\binom{k}{0} a^k b + \binom{k}{1} a^k b\right] + \left[\binom{k}{1} a^{k-1}b^2\right.$

$\left.\binom{k}{2} a^{k-1}b^2\right] + \dots + \binom{k}{k} a^o b^{k+1} + \binom{k}{k+1} a^o b^{k+1}$ (1)

But: $\binom{n}{k} + \binom{n}{k+1} = \binom{n+1}{k+1}$

$\therefore (1) = \binom{k}{0} a^{k+1} + \binom{k+1}{1} a^k b + \binom{k+1}{2} a^{k-1}b^2 +$

$\dots + \binom{k+1}{k+1} b^{k+1}$

$\therefore (a+b)^n = \binom{n}{0} a^n b^o + \binom{n}{1} a^{n-1}b + \binom{n}{2} a^{n-2}b^2$

$+ \dots + \binom{n}{n} a^o b^n$

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International finances, 1997, International Trade, 1997; International marketing, 1997; Prof. Models of Quality, 1996-1998; Prof. Methodology of the Research in Architecture, Industrial Design, Graphic Design, Interiors Design and landscape, 1996- 1998; Prof. Social Research of the Communication, 1996-1998. 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Research, 1996; Researcher DAPA-UAG, 1995-1999; Professor from the University of Guadalajara CUC: Prof. of Differential Equations 2006; Prof. Electromagnetism theory 2001-2006, Prof. Architecture History and Town Planning 2001-2006; Prof. Introduction to experimental methodology 2001-2006; Prof. Thermodynamic phenomenon 2002-2006; Prof. Transit engineering 2002- 2006; Prof. Soil Mechanis II 2004; Prof. Multivariable analysis 2005-2006; Prof. Colour Theory 2005-2006; Prof. Building 2004-2006; Prof. Town planning design 2006; Prof. Watercolour 2004-2006; Prof. Complex Variables 2005-2006; Prof. Distance Learning Theory and Pracitce 2006; Prof. Projects 2004; Prof. Mexican Architecture 2006; Prof. Technical drawing 2004; Prof. Chemistry 2003; Prof. Theory and Educative epistemology 2001-2004; Prof. Educative painting and creative rhochrematic 2001-2006; Prof. geometry 2004; Prof. Numerical analysis 2003-2005; Prof. diferential calculus and integral calculus 2001-2004; Prof. Tenured Professor C (maxim category) 2004-2006; Prof. Sch. Telematic energy 2001- 2006; Prof. sch. architecture 2001-2006; Prof. sch Civil engineering 2001-2006; Prof. Sch. education 2001-2006; Prof. net center, pereira 2000-2001; Prof. Research methods coltepunto, Rionegro, 1979; Prof. Research methods Riotex, Rionegro, 1979; Prof. research methods SENA, Medellín, 1981; Prof. research methods ASSTI, Medellín, 1980-1982; Prof. research Methods Pinturales, Medellín, 1981; Prof. research methods Fallo, M1981; Prof. research methods Viamacol, Medellín, 1982-1983; Prof. of introduction to experimental methodology, 2001-2003; Prof. of Soil Mechanics II, 2001-2002; Prof. of Evaluation of Projects, 2003; Prof. of Transit engineering, 2002-2003; Prof. of Thermodynamic Phenomenon, 2002; Prof. Differential Calculus and Integral Calculus, 2001-2002; Prof. of Electromagnetism Theory, 2002-2002; Prof. of Architecture History and Town Planning, 2001-2002; Prof. of Theory and Educative Epistemology, 2001-2002; Prof. of Research and Develop I, 2002; Prof. of Educative Painting and Creative Rhochrematics, 2001-2002; Prof. Advisory of Thesis in Postgraduate, 2001-2002; Consultant in Administration, Costs, Numismatic, Production, Reengineering, Philately, Lepidopterology, Rionegro, 1983-1996; Consultant in Epistemology, Rhochrematics, Guadalajara, 1983-1996; Consultant in investigator's fields in the National Service of Learning, Medellin, Colombia, 1981; in the Superior Academy of Industrial Technical Services, 1980-1996; in the Modern Institute of Education, 1982-1985; Advisory in the Center of Educational Research, University of Antioch 1983-1986. Adviser in Research in the University San Buenaventura, 1985-1987; Advisory of the UNESCO, 1983-1999; Advisory in Planning and Development, in the Company of Reforestation, The Floresta, Rionegro, Antioch, Colombia, 1980-1984; Advisory in Marketing and Administration in the Companies: Dometal, 1986, Riotex, 1979, Coltepunto,1979, Company of Packings, CORP., 1982, in Medellin, Colombia. Advisory in Production and Costs in House of Kings, Furniture of Style and Decoration, 1980-1981, Medellin, Colombia. Assistant of Production in Dimadera, Design and Decoration, 1981-1984; Medellin, Colombia. Director in the CREAD, Technological Institute Pascual Bravo, Rionegro, Colombia, 1985-1986: Prof. of basic mathematics in the School of Mechanical and Electric Engineering, Colombia, 1985: Administrative adviser in the Modern Institute of Education, Medellin, Colombia 1984-1987; Prof. in Administrative Techniques in the School of Public Administration, ESAP; Medellin, Colombia, 1986: Prof. in General Accounting, ESAP, 1986, Prof. in Ecology in Civil Engineering, in the School of Engineering of Antioch, Colombia, 1987; Prof. in the Methodology of the Research in the School of Industrial Technology Jaime Isaza Cadavid, Institute Colombian Polytechnic, Rionegro, 1986-1987; Prof. of Practical Industrial, Coordinator of Practical Industrial, Colombia, 1986-1987; Prof. of Methodology of the Research in the School of Civil Constructions 1987; Prof.

of Practical in the Colegio Montessori, Medellin, Colombia, 1982. Author of: "Quality and Social Impact", 1986; "The Open Education", 1986; "Computers in Education: Their Teaching, Research and Languages" 1992; "Methodology of Incidence of Malocclusions in 3 to 5 year old Pre-School Children", 1994; "Methodology of Incidence of Cavities Related to the Bacterial Plaque in 3 to 5 year old Pre-School Children", 1994, "Methodology of Oral Habits in 3 to 5 year old Pre-School Children and its Consequences in Primary and Dentition", 1994; "Methodology of the of Baby Bottle Syndrome in 3 to 5 year old Pre-School patients", 1994; "Methodology of Predictive Analysis of Moyers Space in the Arches of Subjects during Mixed Dentition", 1991, among other works. He is also author of numerous Articles it has more than enough Research and Education in the areas of Methodology of the Research, Statistic, Quality, Prospective, Rhochrematics Planning Strategic, Costs, Educational Systems and the Mathematics Pedagogy. Individual exhibitor of paintings in oil and watercolor, among those that are included: "Other Parts of the Universe", New York, United States, 1995; "Mountains and tree", Phoenix, Arizona, United States, 1994; "Hoist", Boston, Massachusetts, United States, 1990; "Canyon", Salt Lake City, Utah, United States, 1989; "Three Mountains", Seattle, Washington, United States, 1993; "Lake and Mountains", Sidney, Australia, 1994; "Mountains and Cypresses"; Copenhagen, Denmark, 1994; "Beach", Long Beach, California, United States, 1995; "Volcano", Purace, Cauca, Colombia, 1990; "Peninsula", Honolulu, Hawai, United States, 1994; "Cypress", Cambridge, England, 1992; "Shadow of the tree", Sao Paulo, Brazil, 1995; "Moon and Venus", Guadalajara, Jalisco, Mexico; "Eucalyptus", Sydney, Australia, 1990; "Five Trees", Johannesburg, South Africa, 1992; "Two Trees", Tokyo, Japan, 1988; "Hudson River", New York, United States, 1991; "Many Pine Trees", Augusta, Maine, United States, 1991; "Several Trees", Washington, D.C., United States 1992; "Several Mountains", Denver, Colorado, United States, 1988; "To Start the Day with the Sun", Charlottesville, North Carolina, United States, 1990; "Volcano and Peak", Purace, Cauca, Colombia, 1990; "The Beginning of the Day with Cypresses", Spokane, Washington, United States, 1989; "Mountains with clouds", Cheyenne; Wyoming, USA, 1988 "To Happen in the late Afternoon in the Beach" Miami, Florida, United States, 1989; "Part of the universe", Boston, Massachusetts, United States, 1989; "Lake and Trees", Duluth, Minnesota, United States, 1989; "To Start the Day with Trees", Scranton, Pennsylvania, United States, 1988; "Five Mountains", Knoxville, United States, 1988; "Volcano and Clouds", Purace, Cauca, Colombia, 1994; "Mountains and Clouds", Lincoln, Nebraska, United States, 1994; "The Beginning of the Day and Clouds", Birmingham, Alabama, United States, 1993; "Three Pine Trees", Rochester, New York, United States, 1992; "The Desert", Tucson, Arizona, United States, 1990; "Volcano and Mountain", Purace, Cauca, Colombia, 1991; "To Start the Day and, Trees", Hartford, Connecticut, United States, 1988; "Desert and Clouds", Tucson, Arizona, United States, 1988; "Moon and Cypresses", Guadalajara, Jalisco, Mexico, 1989; "To Start the Day and Clouds" Miami, Florida, United States, 1988; "Lake and Moon", Chapala, Jalisco, Mexico, 1990; "Mountains and Lake", Denver, Colorado, United States, 1995; "Volcano and Brimstone", Purace, Cauca, Colombia, 1991; "To Happen in the late afternoon and Sea", West Palm Reach, Florida, United States, 1994; "Volcano and Clouds", Purace, Cauca, Colombia, 1992; "Lake, Moon and Trees", Chapala, Jalisco, Mexico, 1993; "Mountain and Gases", Tacoma, Washington, United States, 1993; "Volcano and Gases", Purace, Cauca, Colombia, 1994; "Desert and Shadow", Tucson, Arizona, USA, 1995, "Desert and Gases", Tucson, Arizona, USA, 1991, "Volcano and Trees", Purace, Cauca, Colombia, 1990, "Everest mount", Nepal, 1988; "Pine Trees, Lake and Mountains", Denver, Colorado, United States, 1989; "Mountains and Moon", Guadalajara, Jalisco, Mexico, 1989; "To happen in the

Late Afternoon and Sea", St. Petersburg, Florida, United States, 1995; "Desert and Heat", Tucson, Arizona, United States, 1991; "Lake, Moon and Clouds", Chapala, Jalisco, Mexico, 1988; "The Beginning the Day, Gases and Trees", New York, United States, 1992; "The Beginning of the Day, Clouds and Trees", New York, United States, 1989; "Lake and Vegetables", Denver, Colorado, United States, 1988; "Sea and Mountains", Vancouver, Canada, 1989; "Sea and Gases", Eureka, California, United States, 1990; "Shadows and Desert", Tucson, Arizona, United States, 1993; "To Start the Day and thunderstorm clouds", New Haven, Connecticut, United States, 1992; "Lake, Thunderstorm and clouds and Moon" Chapala, Jalisco, Mexico, 1994; "To Happen in the Late Afternoon and Beach", Galveston, Texas, United States, 1991; "Mount Everest", Nepal, 1998; "Pines, Lake and Mountains", Denver, Colorado, United States, 1989; "Mountains and Moon", Guadalajara, Jalisco, Mexico, 1989; "To Happen in the Late Afternoon and Sea", St. Petersburg, Florida, United States, 1995; "Deserted Heat", Tucson, Arizona, United States, 1991; "Lake, Moon and Clouds", Chapala, Jalisco, Mexico, 1988; "To Start the Day, Gases and Trees", New York, United States, 1992; "The Beginning of the Day, Clouds and Trees", New York, United States, 1989; "Lakes and Vegetables", Denver, Colorado, United States, 1988; "Sea and Mountains", Vancouver, Canada, 1989; "Sea and Gases", Eureka, California, United States, 1990; "Shadows and Desert", Tucson, Arizona, United States, 1993; "To Start the Day and thunderstorm Clouds", New Haven, Conneticut, United States, 1992; "Lake, thunderstorm and clouds and Moon", Chapala, Jalisco, Mexico, 1994; "To Happen in the Late Afternoon and Beach", Galveston, Texas, United States, 1991, among others. Author:

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