

The Systemic Thinking in the passage from the arithmetic language to the algebraic language with use of mediator software Excel (in the children of 9-10 years)

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1.0 THE SYSTEMIC THINKING

The phrase "*Systemic Thinking*" stands for a way to interpret the reality, whose history is fairly recent, since it began developing in the postwar period. The first phase of its development begins in 1940 with the publication of the article *Der Organismus als physikalisches System betrachtet di Ludwing von Bertalanffy Der Organismus*, in which they face the importance of self-regulation of processes of negative retroaction, inside essentially closed systems. At first during this phase, experts of engineering and cybernetics, physicists, and neurobiologists work on projecting and building machines able to auto-regulate themselves, from which the first computers were born. Even if the main attention turns on the world of technology, some key ideas of the systematic thought also began to spread in other disciplinary fields.

Thinking in terms of systems has different advantages:

- It allows us to face complex problems with more consciousness, without getting into the technical details of the subject;
- It discloses structures and behaviors at a high level of abstraction, completely independent from the specific field of investigation. Therefore, what we learn in one kind of system can then be applied to another, also very different: the mental picture of reference is the same, for biological, social, political, environmental... systems;
- It allows us individuating strategies of more effective action, in complex circumstances, where otherwise having a qualitative idea of the action result would result difficult.

A primary characteristic of this approach is the holistic vision.

The *Systemic Thinking* presupposes a series of changes in the mental and perceptive perspective, with which the reality will be faced. The art of thinking, like Alberto Oliviero (1999) says, is also the art of giving ourselves problems that grow as soon as that our mind becomes more powerful and more complex. The thought is not unique, it is based on different kinds of intelligence: logic, analogical, visual, motor, and systematic. When we face a problem, we use all kinds of intelligence, however, in the setting phase, the most used thoughts are the logical, analogical, and systemic. Instead, the systematic thought creates synthetic visions of very complex situations, which are rich of interdependent data. It presupposes building inside the mind global scenery that represents the system of reference on which we have to locally work. Licon Khisty (1997) defines the systemic thought resembling a philosophy that suggests of "globally thinking and locally acting" and that takes off from the vision of reductionism or thinking in terms of isolated part, which is a mechanistic model. It is applied in varied areas of the real life, like a tool for systems of analysis and representation: economic systems, electoral systems, educational systems, etc...

Enrica Lemut, during the last years, conducted some researches to verify how and why some software of mathematical application, which is used like a general tool for problem solving and for some mathematical competences, can play the role of mediator supporting and creating the conditions for the development of systemic thinking. The connections between the ability of thought in systemic terms and the algebraic model characterize another field of exploration, using the electronic sheet like working code. My research proposes to verify or falsify E. Lemut's experimental hypothesis, considering children of elementary school, mostly nine years old, and introducing with Excel the passage from the arithmetic language to the algebraic language.

2.0 ALGEBRA IN THE PRIMARY SCHOOL

It is known that many students of the secondary school have difficulty in learning Algebraic language, many authors have noticed that a prevalent factor is the incapacity to put symbols in relation to meanings. The existent literature shows that this phenomenon must be investigated by analysing the cognitive aspects and the didactic implications. The students ignore the correct meaning of formulae and errors, and they even invent surrogates of meanings. They can't master the symbol and it seems that they are incapable of using algebra as an instrument of thought, in order to understand generalizations, to grasp structural analogies and to discuss maths. The roots of some conceptual

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errors are in the primary teaching. At this scholastic level, in order to avoid future obstacles and misunderstandings, it is important to underline the relational aspect of the number, by accustoming the children to associate each number with a multiplicity of different representations, by using arithmetical expressions. In the didactic practice it is necessary for the children to practice with equivalences of this type: $3+4 = 6+1$ $3 \times 5 = 10+5$. These exercises underline the aspect of numerical representations, by understanding their interchange ability, in order to realize a right balance between the procedural aspects and the relational aspects in arithmetic and to favour a more agreeable approach to algebra. Of course in primary school it is impossible to teach the Algebraic language to children but its introduction is possible. According to A. Malara (1996) the Algebraic language should be taught as a natural language. In fact, grammar and syntax, analysis of the terms, symbols, conventions for the generalization of expression and rules of transformation should be taught. To teach, moreover, to translate from one language to another, by reading and interpreting formulae in Algebraic language and vice-versa, by expressing in formulae sentences of the ordinary language. To teach to express one's ideas with the new language and to deal with more and more complex problems in the course of the years. The software Excel can be considered a mediator between the arithmetical language and the Algebraic language.

3.0 THE SOFTWARE EXCEL: INTRODUCTION TO THE ELECTRONIC PAPERS.

Excel is a software for paper computation, which memorize units of information in papers of work. These are the applications which allow the exploitation of potentiality of computation of the p.c. and they are based on a working area, called electronic papers which consists of a grid of lines and columns. The cell, which is the intersection between a line and a column, is the elementary unit of a paper of work, and it can contain a datum of the text or formula. The formulae are the fundamental elements for working with Excel. By using these you can do additions, subtractions, and more complex computations. A formulae is different from a constant datum, because it is different from a constant datum because it starts always with a the equal sign. this indicates to the program that the following characters are the elements to calculate (the operators, separated by the logical operators of the text or the mathematical operator) e.g.: (= a6*a7; = b1/b4)

The application calculates the formula from left to right, on the grounds of a specific order for each operator of the formula. It is possible to change the order of the operations by using the brackets.

In order to make the grammar of Excel clearer the following table shows the various ways of writing the same formula by using the language of Excel, the language of Algebra and the natural language.

EXCEL	ALGEBRA	NATURAL LANGUAGE
$= A4*(A7+A9)/B5$	$a4 (a7+a9)$ $b5$	must be multiplied a4 by the addition of A7+A9 and then the result must be divided by B5

This short description shows clearly that the syntax of the software, its grammar and the control display, the roll of the variable quantity and introduce a precise symbolic system. The references to the cells, through their co-ordinates, are used for identifying the cells to which the formula must be applied. For my research only the arithmetical operators were used.

4.0 THE HYPOTHESIS

The experimental hypothesis of my research is the following: "If the electronic paper of Excels a mediator in the solution of problems, then the conditions for the development of systematic thought are supported and created". The study of E. Lemut about the analysis of mental processes which are put into activity during the study of an open situation, shows that programs like Excel (which implicate strong representational systems) and suitable thematical capability, can be mediators in the support and creation of the conditions for the development of the *Systemic Thinking*. The analysis shows that:

- the activity of the problem solving needs the capability of the student to perceive and extricate gradually the system which is the nucleus of the problematic situation;
- to achieve a global vision of the situation;
- to be able to understand and use mathematical models Algebraic models, and the model"
- search objective of Excel;
- formalize local actions which describe particular relations in the system;

- to reason about local relations which are quite formulised , can improve the capability to think a system over totally and to reveal aspects which otherwise could be hidden.

5.0 THE PRE-TEST

The experimental part of the work was preceded by a reflection upon the theoretic construction and the didactic implications. The formulation of the experimental project was anticipated by a pre-test which I gave to 3 boys of different age sin the summer of 2001 in order to examine a heterogeneous sample and to get the first information about it. these boys 9,11,and13 lived in different towns and they different scholastic experiences. Their reflections were very important.

5.1 THE NEW EXPERIMENTAL PHASE CONTEXT COMPARED TO THE PRE-EXPERIMENTAL PHASE.

The sample consists of 30 9 year olds who attend the 4th. year of the primary school " of the comprehensive institute of Palermo. The hypothesis was tested on Dec.2001. Owing to the complexity of the didactic situation the resolution of the problem was obtained in couples. I asked the children to reflect aloud, to write on a paper the hypothetic solution and finally only when they are sure to resolve it with Excel. Owing to the reflections which derived from the analysis of the cases of the interviews afterwards I decided to change the text of the problem by making it more linear in the reading and so more comprehensible. I re wrote the text: "A factory produces 1200woolen vests a month. In order to make one it spends 7000€ for the wool, £ 1,200.for the labour and 800€ for packing if the profit of one vest is 9,120€ what is the cost on the market of each product? and what is the annual profit?"

6.0 A PRIORI ANALYSIS

However, the aprioristic analysis does not present specific variables that underline the passage from the arithmetic language to the algebraic language, rather than those that represent the systematic thought. In the resolution of the problem with the electronic sheet, the (variable) strategies that the sample has presented are the followings:

Variable	Description → global thinking
a1	he writes all data of the problem in the boxes independently from the operations that he must do.
a4	he does not write down the implicit data, but he expresses them in the operations.
b2	he reads the text of the problem only once.
b3	he reads the text of the problem more times before making decisive hypotheses
b7	he develops wrongly the operation of the sum, since he also adds the number of the shirts.
b8	he makes a mistake calculating the proceeds; he subtracts the profit from the expense.
c1	he multiplies the expense of a shirt for the number of the shirts that have been produced in a month.
c4	he finds first the profit in a year, and therefore he is not tied up to the sequential order of the text.
d3	with only one operation and one formula he finds the annual profit: he multiplies the profit of a shirt to the number of the shirts and to the number of the months in a year.
d7	he multiplies the profit of a month to the number of the months (without making explicit the number 12).
d8	resolving the second question, he remembers the information drawn from the resolution of the first global question.

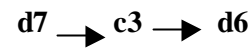
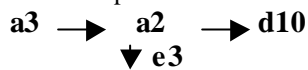
Variable	Description → local thinking
a2	he writes the data of the problem that he needs for the resolution of the operations
a3	he writes in the electronic sheet the implicit data too.
b1	he looks for information in a way to find hidden relationships inside its data that could tell him what he wants to know.
b5	he needs to formalize the new relationships that he has found in the system in mathematical terms.
b6	he develops the operation of the sum that allows to calculate correctly the total expense of a shirt.
c2	he multiplies the expense of a month to the profit of a shirt.
c3	he multiplies the profit of a month to the number of the months in a year.
d1	he decides to first find the proceeds of a shirt.
d2	he adds the expense to the profit.
d10	he correctly develops the operation of total profit.
d11	he correctly develops the operation of profit for only one shirt.
d12	he finds the annual profit multiplying the number of the shirts to the profit of one shirt.

Variable	Description → systemic thinking
e3	he does not have difficulty writing the formulas.

6.1 IMPLICATIVE ANALYSIS USING THE CHIC PROGRAM

The graph of the implications underlines that:

1. The variable **a3** (he writes in the electronic sheet the implicit data too, which is the number of the months of a year) implicates the strategy **a2** (he writes the data of the problem that he needs for the resolution of the operations);
2. The variable **a2** (he writes the data of the problem that he needs for the resolution of the operations) implicates the strategy **d10** (he correctly develops the operation of total profit);
3. The variable **a2** (he writes the data of the problem that it needs for the resolution of the operations) implicates the behavior **e3** (he does not have difficulty writing the formulas);
4. The variable **d7** (he multiplies the profit of a month to the number of the months in a year without making explicit the number 12) implicates **c3** (he multiplies the profit of a month to the number of the months in a year);
5. The variable **c3** (he multiplies the profit of a month to the number of the months in a year) implicates **d6** (he multiplies the number of shirts in a month to the profit of a shirt).



7.0 CONCLUSIONS

I think it is opportune to say that our main intent was to produce a formative intervention that would allow favorable conditions for the development of the Systemic Thinking in students of elementary school. The results of the research underline that the introduction of the electronic sheet, in the process of teaching learning of the mathematics, allows to globally think and to locally act. My search supports E. Lemut's conclusion (2000). This generalization strengthens the concept according to which adequate mathematical acquaintances and software of Excel application play the role supporting and creating the conditions of the development of the Systemic thinking. From the analysis of the received data, we have underlined that whoever enunciates in the electronic sheet the implicit data too, he writes all the data of the problem. That implicates the facility in the process of writing and producing formulas with Excel, therefore also the correctness of the operations. Because of Excel structure, characterized from many cells, and because of its skillful system of representation, it is possible that the student:

- creates a systematic table that represents the data of the problem, the relationships between them and the results that they want to be reached;
- chooses any box where it is possible write the figure. That allows the child to move with more freedom in the spreadsheet, giving him a sense of autonomy and of creativeness;
- has the possibility to contemplate the situation from different perspectives, from the point of view of the store and that of the future buyer, expanding as the own systematic vision of the situation;
- interacts continually with the sheet in way from create conjectures I concern ulterior relationships between the elements of the system;
- elaborates again the formulas, for globally thinking and locally acting;
- applies the generalization of the formulas;
- independently creates the visual reinforcement, making a double click on the underlined box;
- begins to compare his mistakes, saving the previous calculations in the 2nd spreadsheet.

The research allowed us to underline cognitive and operational processes that become active using this didactic methodology. The students' attention focuses on the way of operating with a new symbolic code and not only on the operational executions. It is necessary, during the resolution process of the problem, identifying the system on which operating, the interpretation, and discovering relationships inside the same system. That implicates an effort by the student, which, interacting with the electronic sheet, must respect syntactic rules and subtended semantics. Satisfying the descendant's curiosity is possible through the formulation, the validation and the verification of conjectures, getting to a better understanding of the given system. Moreover, the software offers a big variety of techniques of representation, of inherent functions, encouraging and stimulating the visualization of matters from different points of view and analyzing the meaning of specific given information. The results, however, cannot be called definitive; in fact, I will go on my research subsequently integrating the implicative analysis with qualitative evaluations.

OPEN PROBLEMS

- Ulterior information can be harvested by improving the tool of investigation, building a more detailed analysis a-priori, and widening the sample of investigation.
- An example of open problem could be the analysis of supplementary variables, which could correspond to ideal students' profiles.
- Besides, applying the research on *Systemic Thinking* in other cultures and in other natural languages would be interesting, for instance on the Chinese children, which present a way of thinking different from ours. (Spagnolo, 1986)

- It is necessary to widen the investigation on the cognitive processes that are activated during the passage from the arithmetic language to the algebraic language.
- Remember that the use of the computer allows us to create an environment in which deducing and conjecturing is possible.
- An ulterior field of investigation is verifying whenever other computer mediators could develop the *Systemic Thinking*.

APPENDIX

On the grounds of the results obtained by the research and by embracing the idea that the software Excel and some mathematical competences create the conditions for the development of the systemic thinking thought and introduce the passage from the arithmetical language to the Algebraic language. I decided to realize a didactical intervention which starts the use of the p.c. in the above mentioned terms. I wondered which sort of didactic route can introduce the activities with Excel. Is it necessary that the children have some specific notions? Which notions?

The apprenticeship permitted me to do the experiment and let me do in the class the route which I describe now: In order to formulate the aims, I used as theoretic reference the S.O.F.E.(system of the fundamental aims of education) in order to put the intellectual functions, which must be stimulated, in relation to the observable basic abilities., the control metacognitive processes in the problem solving and the performances. It was possible to evaluate the results of learning and mostly the processes by which they are obtained., without reducing the importance of the personal success.

The didactic intervention is imbued with the didactics for concepts and with the metacognitive didactics, the technique of management is the brainstorming. the title of the unit of work is emblematic, in fact it anticipates the notions, the competences and the attitudes the children have mature, in order to resolve a problem of marketing with the software Excel. During the management we involved the same children who con attitude the sample of the research and their schoolfellows.

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