

PROGRAMME OF INTERVENTION TO ENCOURAGE PROBLEM-SOLVING SKILLS AND PERSONAL DEVELOPMENT IN THE CLASSROOM

Researchers: Gladys Riquelme del Solar
María del Valle Leo
Nancy Toloza Jopia
Eduardo Mardones Fuentes
UNIVERSITY OF CONCEPCIÓN

I INTRODUCTION

Since 1996, Chile has been undergoing a process of educational reform centred on, among other things, promoting pupils' autonomy in school work, their participation in class, and their development of problem-solving skills. Furthermore, Chilean education has been imbued with the idea of strengthening our children's personal development.

Bearing this in mind, as well as the results attained by primary school pupils over the past few years in our system for measuring quality in education, it has become evident that we need to enhance our students' capacities in order to enable them to arrive at higher performance levels. Special attention must be given to their problem-solving skills, by which we mean their ability to search for relationships between pieces of information which are connected to a given problem and the subsequent arithmetic resources which allow them to solve that problem. Our emphasis here is not placed upon "operational resources" but upon the intellectual skills which allow pupils to arrive at "elaborative thinking" which will later evolve into the capacity to interpret, relate, analyse and synthesise processes using more complex intellectual levels (like what Schmeck calls "deep processing").

The aim of this piece of research is a pedagogical practice related to solving problems using *evaluative strategies* (especially those centred on *processes*). It thus presented pupils with different problems which they then had to solve using processes and procedures. It made it possible to identify the difficulties each pupil has as well as to promote learning through the organisation and mental structure that the pupil must use in

order to tackle and solve problems. As well as the assessments that they underwent during the research, the pupils used rubrics to evaluate themselves and to express their level of satisfaction.

The investigation was sponsored by the University of Concepción's Research Centre (DIUC) - project no. 99.162.039-1.0. It was organised and planned in light of the research experiences had by the University of Concepción's Teaching Centre, innovative evaluative strategies (Riquelme and Marín, 1998) plus investigations previously carried out by the Research Centre related to problem-solving teaching materials (Del Valle and Zamora, 1996).

Both centres worked with the so-called "4 steps-10 solutions" technique, teaching material created exclusively to stimulate pupils' ability to solve problems. The material was used with primary school children in years seven and eight in the Arauco region of southern Chile. It made possible the development of many methodological strategies to induce sequentially the pupils' capacity for reflection and understanding. However, evaluative strategies which would complement these methodological efforts were not incorporated and, consequently, the emphasis of this investigation has not yet been placed on the validation of the material but upon its complementation, so as to throw light on the cognitive processes that each of the pupils employs to face and solve contextualised problems. This is why our evaluative approach is more qualitative and holistic in character.

At the same time, our research did provide a system of assessment which permitted the progressive, gradual collection of information about the acquisition of intellectual skills required to solve problems under natural conditions.

II THE CHARACTERISTICS OF OUR RESEARCH

This piece of research was founded on a quasi-experimental design (Arillaco, 1988) and included pre-test, intervention and post-test for an experimental group and a control group. During this first stage, in which partial results of the investigation were obtained, the

MacNemar test was used to verify the significance level of the changes observed in the dependent variable.

Population and sample: The investigation was carried out in two schools (*Bellavista* and *G. Mistral*) in the town of Tomé, with 70 boys and girls from year seven at primary level participating. The sample is not probabilistic, since it relied upon the authorisation of the schools' Head Masters and upon the spontaneous collaboration of the pupils' Maths teachers.

The programme of intervention (*experimental variable*) involved a methodological strategy for solving problems, as well as evaluative procedures. The aforementioned strategy encourages school children's cognitive skills and proposes four steps to approach the problems, as well as providing many alternative solutions. The evaluation guides the student, as he advances from one step to the next, towards reflection. The strategy employed also stimulates pupils' logical mental structure as they deal with the problems. It is assumed that through these relationships the methodological strategy, accompanied by an holistic assessment and applied in the natural working conditions of the classroom, will contribute to a strengthening of problem-solving skills and personal development (*dependent variable*).

This article sets out the advances and achievements that have made possible an information platform of great significance.

Although it has not yet been possible to verify our original hypotheses, it is valid to point out that, if we take the entry conditions obtained in the pre-test as reference, our findings permit us to infer an important improvement in the pupils' skills.

Among the proposed objectives of the investigation, we can cite the following:

1.- To strengthen the pupils' capacity to solve problems through the use of evaluative strategies (related to processes) and an holistic qualitative approach.

2.- To create an evaluative system in order to obtain information under natural conditions and thus determine the individual pupil's acquisition of the intellectual skills required for the progressive, gradual resolution of problems.

Theory and empirical evidence teach us that there are variables which influence academic performance (*dependent variable*) (Segure, Solar and Riquelme, 1995). This piece of research gathered information about how these variables develop for individual students and for classes of students. A test battery was applied in order to obtain a diagnosis of the level of each pupil and each class for the following attributive variables: *Self-esteem*, which was measured through a Chilean version of the Coopersmith test (Brinkman, Segure and Solar, 1989); Riquelme and Constenla's *Reading Comprehension THLB* (validated in 2000 [Riquelme, Constenla and Cerda]); *Learning Strategies* (Trufello and Perez, 1988) and validated *Logical Intelligence* (Riquelme, Segure and Yévenes, 1991). Finally, the dependent variable *Problem-Solving Capacity* was measured through a Problem-Solving Test (Del Valle and Zamora, 1997). These variables explain the student's intellectual and personal development and all of them have special relevance during the pre-adolescent stage. Each pupil's profile was incorporated in the information platform; the pupils' different psychosocial characters were thus integrated into the programme of intervention.

The characteristics of the problem-solving method: The "4 steps-10 solutions" method is designed to develop pupils' ability to solve problems. The method encourages the use of 4 steps that pupils should follow when tackling a problem and, at the same time, it suggests 10 different ways of solving the problem, according to the level of cognitive development of the people trying to solve the problem and the nature of the problem itself.

The 4 suggested steps are:

- FIND OUT what the problem means and what questions you have to answer.
- CHOOSE a strategy which enables you to solve the problem.
- SOLVE the problem.
- CHECK the process you used to solve the problem.

The 10 solutions are:

- Act or use objects.
- Do a drawing or draw a diagram.

- Use or make a chart.
- Make an organised list.
- Revise and check.
- Use or try to discover a behavioural pattern.
- Go back.
- Use logical reasoning.
- Simplify.
- Brainstorm.

The characteristics of the assessment: On the one hand, the proposed evaluative system examines problem-solving skills and, on the other, promotes the pupil's self-image. It provides the teacher with information related to the steps which trouble the pupil, so as to orient him (or her) in the search for the solution and the procedure most suited to the problem.

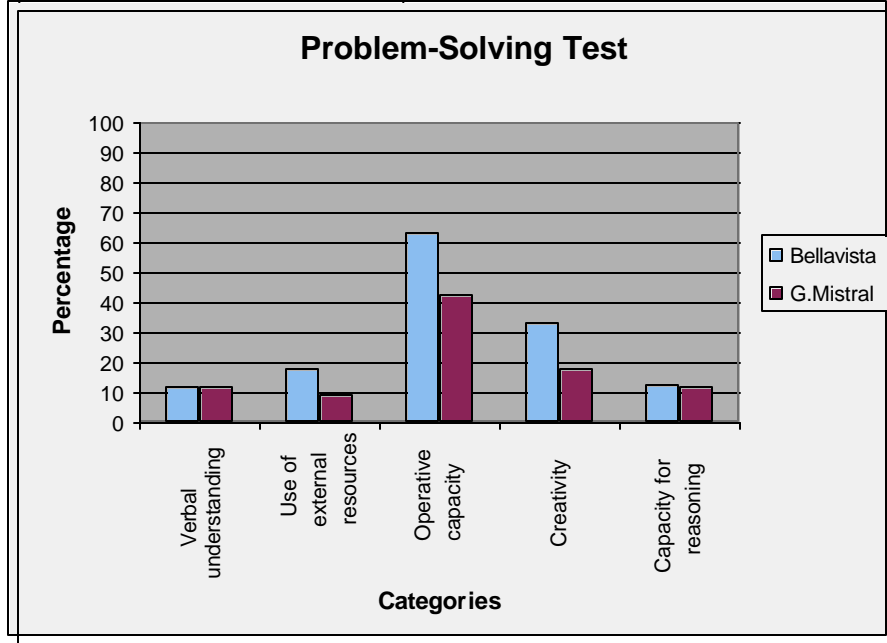
Although these assessments enabled us to detect the pupils' weaknesses, the pupils themselves have not perceived these weaknesses as failures since activities are provided which are designed to counter their shortcomings. As the pupil advances through the "4 steps-10 solutions" programme, he incorporates the new skills which it stimulates.

III RESEARCH METHODOLOGY

The first intervention in the experimental groups was the application of a test battery where information was obtained about the attributive variables and the dependent variable.

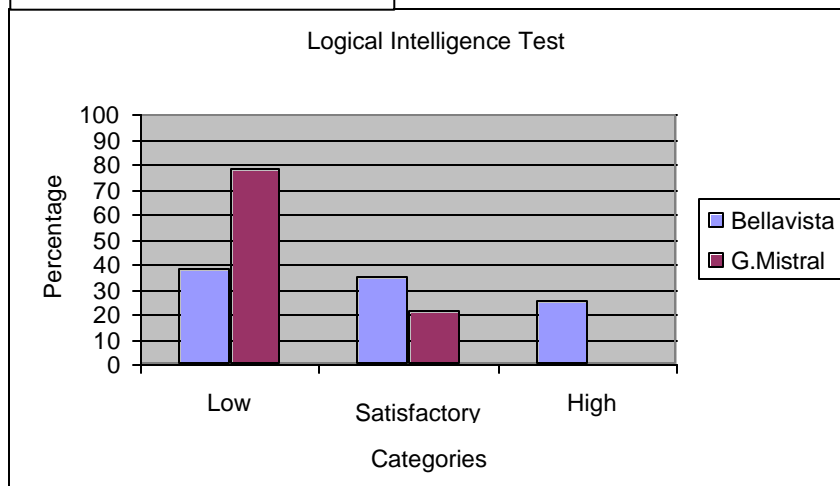
The following data was gathered:

Graph 1

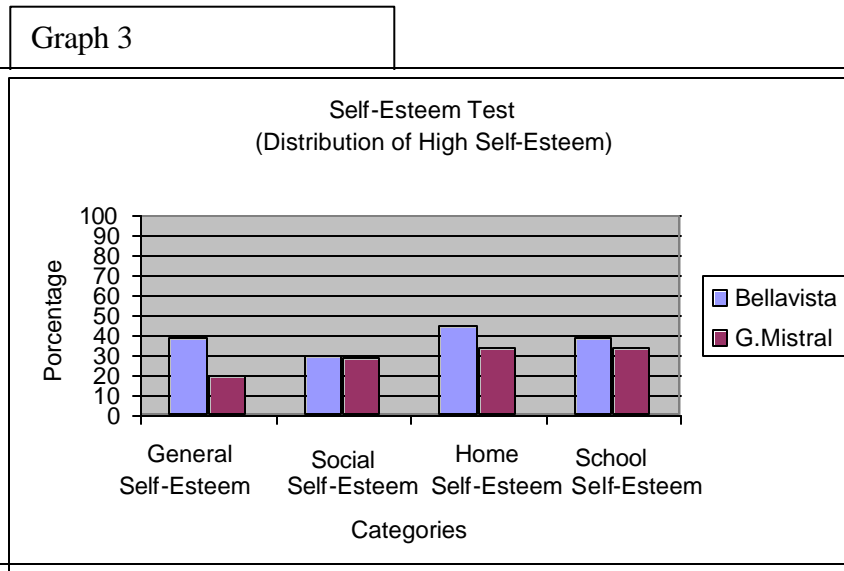


The graph above illustrates that the pupils' only well-developed skill was their operative capacity (60% and 40% respectively). All the other skills evaluated by the test were very underdeveloped.

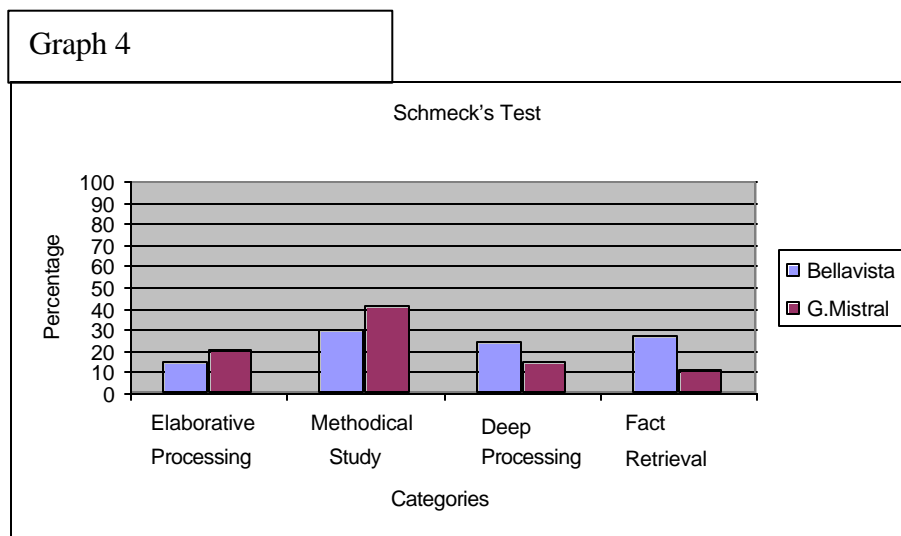
Graph 2



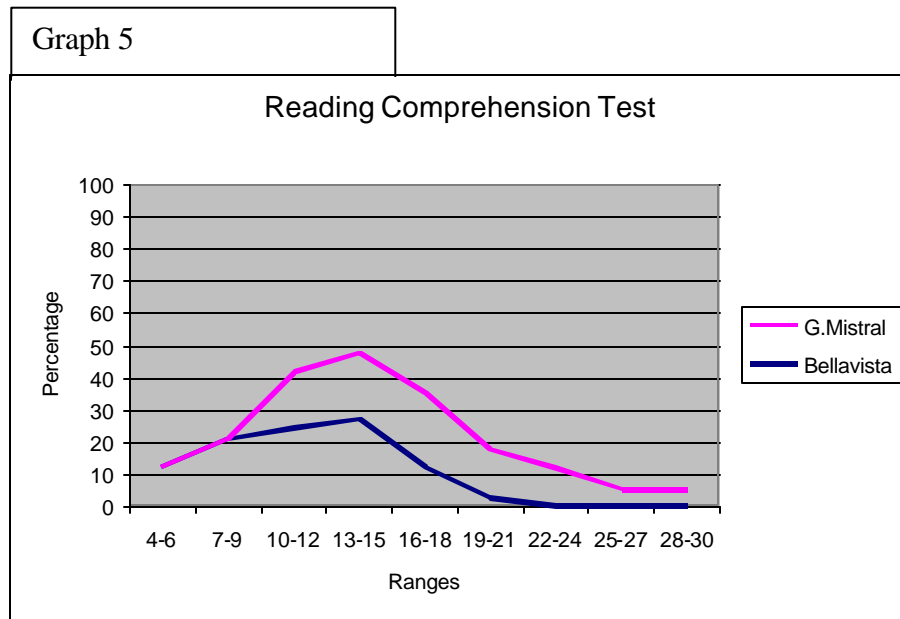
The data shows that a high percentage of the pupils are still in the “concrete operation stage” (according to Piaget’s theory of cognition). This explains the difficulties that they had with processes of abstraction when they were trying to solve problems.



It should be emphasised that only a small proportion of the pupils exhibited a satisfactory or high level of self-esteem.



According to our observations, these children (whose average age was 13.5 when the tests were held) did not demonstrate any clear tendency with regard to the learning strategies that they use.



A significant proportion (33%) of the pupils got between 13 and 15 points in this test. Given that the test has an ideal score of 45 points, this shows that their reading comprehension is not sufficiently developed,.

In summary, the data obtained from the variables and the test results revealed that the majority of the pupils were in what Piaget called the concrete operation stage. Generally speaking, many of them exhibited a low level of self-esteem. Moreover, the pupils only rarely demonstrated the predominance of a particular learning strategy. As for the reading comprehension, 98% of the pupils failed to achieve a minimum score in individual skills or globally speaking. In the case of the problem-solving variable, 90% of the pupils failed to attain the problem-solving capacity even when an arithmetic operation was not required to find the solution. To a large extent, this diagnosis reflect the sad reality of our country's educational system.

Parallel to these measures, we worked in teams with the teachers in charge of the courses, who were informed of the results of our diagnosis of their students. The teams agreed on the method of working with the material that describes the possible problem-solving strategies. These strategies were contextualised with the theme/content of the courses involved as a reference, in order to avoid interrupting the planning already done for the academic year 2002, and at the same time to take into consideration the socio-cultural and experiential environment of the pupils' everyday lives.

With these antecedents, the process of intervention started. This was planned from the simplest strategy, gradually increasing in complexity according to the results of the non-assessed evaluations. Faced with this teaching-learning process, we consciously worked with teaching material which encouraged problem-solving capacities.

After the process of intervention had started, during which the pupils had to solve problems using the "act or use objects" and "draw" strategies, an evaluation of processes was given, with the aim of finding how well the pupils could apply the things they had learnt in order to solve problems which had been contextualised and which did not require arithmetic calculations.

The other purpose of this evaluation of processes was to discover how pupils looked at problems, and what they did while solving them. This was achieved through open questions which pupils answered. The questions were ordered in relation to the logical steps which had to take place in order for the student to approach and solve the problem. Put another way, the pupil was guided by set types of stimuli so that he could become conscious of how he was tackling the problem, how he proceeded and what elements he took into consideration during his reasoning.

The results of this first intervention were not satisfactory. In both schools, it was observed that just 33% of the pupils applied the strategies successfully. It is important to note that the great majority who successfully solved the given problem did so through the concretion of the elements involved while a small minority did so through graphic representation.

Having analysed the pupils' answers to this first evaluation of processes, it became obvious that, whether they answered the problem correctly or not, all the pupils could at least identify what they had to do. However, the difficulties they had could often be interpreted as problems with mathematical vocabulary. Alternatively, further problems were observed in the pupils who were incapable of developing a time-space relationship; they were having difficulties relating the given elements to the referent. Interestingly, the results of the reading comprehension test demonstrated a high rate of failure, especially in the parts which required the pupils to identify the relationships between the different elements in a text and their chronological succession.

Another dimension measured within this assessment was the level of satisfaction that the pupils could feel while doing this type of activity. An analysis of this affective dimension revealed that all the pupils perceived that they had learnt something new with this work method.

The pupil's answers also revealed their ability to assess their own performance of the task. 65% of the pupils in both schools criticised their difficulty and/or their competence in solving the problems that they had been given.

Through rubrics, the assessment allowed us to mediate between the pupils and the learning task; they could reflect and do a self-analysis of the tasks they had performed. Furthermore, they could give their perceptions of their own learning and their satisfaction with the activities they had done.

In this first assessment, it was noted that the pupils did not resolve the problem correctly but used the first strategy, "to manipulate objects".

Using the information collected through the evaluation of processes and analysed individually and generally in both schools, it was decided to strengthen some of the pupils' abilities and basic functions which had been revealed as insufficient. This was carried out

through the modules of the Instrumental Enrichment programme, which was applied to all the students in each class. The material used for this intervention is based on Reuven Feuerstein's theory of "structural cognitive modifiability".

The design of the Instrumental Enrichment programme: Given the pupils' low results in both schools, an adaptation was done of the instruments of the first level of Feuerstein's Instrumental Enrichment programme: Organisation of Dots, Orientation in Space I, and Comparisons.

The activities of these different instruments were interrelated in order to reinforce the development of vocabulary and the use of the mental operations needed in Orientation in Space I and Comparisons. Although Organisation of Dots demanded a lower level of vocabulary and reading of instructions, it encourages flexibility, processes of discrimination and the restriction of impulsiveness, abilities which are needed for comparison and orientation in space.

Orientation in Space I was designed with the aim of teaching the management and use of spatial relations and their relativity. This relativity was very low in the students: they had serious difficulties when they had to project spatial relations without motor support, difficulties which were reflected in their low marks while they were learning, reading, writing and doing calculus.

Activities from the Comparisons instrument were included because it was thought that, despite the pupils' low level of vocabulary, the ability to compare was a less developed step for reasoning in general and for categorisation in particular. Thus the Comparisons tasks were oriented towards the teaching and development of thought relationships, a basic component of intelligence (Stenberg, 1985).

The purpose of this intervention was to correct the pupils' deficient cognitive functions; the characteristics of these instruments demanded that the pupils use temporal

relationships and spatial dimensions, a fact which at the same time helps them to restrict their impulsiveness and egocentric behaviour.

The vocabulary as well as strategies learnt are also very relevant to other areas of knowledge like geometry, arithmetic, language and communication, etc.

The continuous and systematic repetition of these different tasks allowed the students to crystallise the problem-solving process. Once the tasks began, the pupils started to see themselves as active subjects and processors of information, participating in the search for problem-solving strategies. Parallel to this, the students continued developing the next strategy suggested by the “4 steps-10 solutions” programme.

As the academic year drew to a close in late November, an evaluative test oriented to examining the results was given, for at least two of the problem-solving strategies which had been dealt with in September, October and November.

IV RESULTS AND CONCLUSIONS

This evaluation included three types of problem of increasing complexity, none of which required arithmetic calculus. The pupils could use any of three strategies to solve the problems. The assessment also included a page designed to find, through rubrics, the pupils' level of satisfaction with the task, their self-criticisms (self-evaluation), and their ability to reflect on their performance.

With the data obtained during this stage of the research and with the aim of checking the changes we had observed in the pupils, a non-parametric test was applied which allowed us to contrast the level of significance of these changes.

The MacNemar test was therefore given and contrasted with the chi-squared test, which was used to determine the effectiveness of the changes in the students who had experienced the programme of intervention.

The results of the two groups being studied were compared. The pre-test, which had measured the students' capacity to solve problems, was expressed in dichotomous terms ("Accomplished" or "Not Accomplished"). This was compared to the results of the post-test, which were expressed in similar terms ("Success" or "Failure"). The result obtained was highly significant: $p = 0.01$, MacNemar result = 6.4 for a chart of 2×2 and degree of freedom = 1.

The results obtained in the evaluation of processes was compared to the post-test. As in the previous comparison, the variables were divided into "Accomplished" or "Not Accomplished", and "Success" or "Failure", respectively: the MacNemar result = 20.16 with degree of freedom = 1 for a level of significance of $p = 0.0005$. This implies that the changes we observed are highly significant and it is therefore possible to venture that the programme as a whole is being effective.

The data, though admittedly just partial results, reveals that the research project is successfully promoting children's problem-solving capacities. It is likely that by the end of the experimental programme, the proposed objectives as regards cognition will be accomplished and that pupils will be able to reach metacognition through our evaluative schemes.

With regard to the changes which the pupils have demonstrated in the affective dimension, 98% of them expressed a high level of satisfaction both with tasks and methodology. They felt that they were participating and they believed that they were learning something new. Furthermore, this has contributed to their becoming conscious about their own performance. They think that they can improve their marks in Maths and thus their expectations have risen.

When the teachers in charge of the courses were interviewed, it was possible to collect some extremely valuable information regarding the pupils' change in behaviour, especially in terms of levels of attention and discipline. The pupils' attitudes have improved and become more positive. It is worth emphasising that one of the classes participating in the project had previously been stigmatised as undisciplined and lazy. The class' teachers recognised the positive change in the pupils, so much so in fact that the school has asked us to extend the programme to other sectors of learning and to lower levels of primary education.

It is important to emphasise that the pupils are aware that they are participating in an experimental programme. Their parents were also informed and they accepted the project with optimism and happiness. This in itself may have contributed to the pupils' greater receptiveness and affected the variables that we have looked at.

At the same time, the pupils participating were provided with didactic materials, which allowed each of them to have their own folder or portfolio. It is probable that all these elements have interrelated to create a propitious atmosphere where the pupils feel themselves protagonists in the programme.

One of the programme's innovations comes from the process of evaluation which includes rubrics which orient the self-assessment, self-criticism, the reflection and the level of happiness with the activities. Moreover, in the assessments the pupils can give their opinions and, at the same time, they are obliged to centre their attention on what they have done and to visualise the fact that their work has improved. For this reason, they have not felt the burden of failure.

The research team concluded that everything that a teacher does with his or her pupils should be creative and innovative. If pupils are assessed naturally, without experiencing anxiety or fear, it is highly productive for their personal development and their self-image.

To summarise: it should be emphasised that if one wants to improve the quality of learning and to give more equality to education when dealing with the teaching-learning process, the students – at least those in primary school – must be considered as a whole. Their psychosocial characteristics give us a point of reference which must be taken into consideration when we endeavour to improve their learning.

These children's weaknesses are the result of a lack of stimulation of the many abilities and skills that they should have developed at an earlier stage of primary education. This is, needless to say, a concern of paramount importance.

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ABSTRACT

This Article presents the advances of a cuasi-experimental research with pre-post test experimental group, whose aim was to develop and improve the abilities to solve problems and to help the student personal development by means of evaluative strategies with a holistic approach and applied under natural conditions. This object is being applied to 7th Primary School students from schools under the Tomé City Council control and the sponsorship of Research Department of the University of Concepción-Chile (N° 99.162.039-1.0)

The control program is based on Hoogeboom and Goognow's 1987 four step and ten solutions method to solve problems. The fulfillment of the process assessing strategies helps to develop a personal version of the subject self-esteem. Comparing the program entrance level of the students with the process and outcome assessment, it can be inferred that , up to this moment, it has been successful because the results obtained by the Mac Nemar's test has been highly significant. (p=0,001)