

Neuro-teaching in Primary School. The principles of Feuerstein's mediated learning integrated into school curriculum¹

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Abstract

The aim of this experimental research is to examine Reuven Feuerstein's educational theory.

By expanding on theories from Piaget and Vygotsky, Feuerstein described a method to teach students how to study through the development of an active structural approach. This is effective for learning because it develops habits for seeking novel strategies when faced with new and complex problems.

The study, after analysing the international literature on the application of the method in Primary School, investigates one of the problems arising from the examination conducted so far: why isn't the Feuerstein's Instrumental Enrichment process consistently affects student performance in all subjects always?

The assumption of this research is that the Feuerstein program cannot influence the academic performance if it is not integrated into the school curriculum. It can be assumed that if the Feuerstein principles of mediated learning were applied to all subjects, a neuro-curriculum can be developed, resulting in a significant improvement in the school performance.

The study consists of a two-year quasi- experiment in a Primary School (2013-2014, 2014-2015). 82 students in the fourth and fifth grades and four IE (Instrumental Enrichment) trained teachers were involved. They were divided into four independent groups (which are equivalent to four classrooms): two are experimental and two are for comparison. Quantitative and qualitative assessment tools will be used before and after the process.

Keywords

cognitive education, mediated learning experience, effect study, teachers attitudes, primary school education, neurocognitive intervention, metacognition

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Introduction

This research project is about a process for integrating cognitive education into a Primary School curriculum. Specifically, it is focused on a complete and systematic program that allows the transfer of knowledge through concrete pedagogical acts: the Feuerstein program. It is a comprehensive learning process that integrates, systematizes and harmonizes within itself different approaches: cognitive, meta-cognitive and psychosocial. The Instrumental Enrichment's (IE) offers a two-fold approach: to intervene when deficient cognitive and metacognitive functions are identified and to stimulate the affective-motivational component of learning through the care of the educational relationship. According to Feuerstein, is not sufficient to simply focus on deficient thinking processes, is necessary to create conditions for the reconstruction of a student's sense of competence and self-esteem, arouse emotions, feelings, and projects that build confidence to face the life's challenges (Vanini, 1999).

Feuerstein's method is a method *to teach how to learn*. The main objectives are:

- to develop an active structural approach which is effective for learning
- to encourage habits for a continuous exploration to identify flexible strategies when facing new and complex problems
- to continue the process of self-expansion of a person's intellectual potential.

Feuerstein's program is based on Piaget's theory about the stages of cognitive development of the child (Piaget, 1965), but it goes beyond that, and on Vygotsky's theory about development potential (Vygotsky, 1986). It is builds on two theoretical principles: the cognitive modification and the learning mediation

According to Feuerstein, brain structures can be modified. Researchers in neuroscience have confirmed this fact. Environmental stimuli, when appropriate, can modify the synapses network and through repeated efforts can become denser and thus aid learning. Knowledge is the matrix of thought. Feuerstein vision moves beyond the position of Piaget and advances towards Vygotsky's theories. An individual's ability to gain the maximum benefit from environmental stimuli is determined by the type of mediated learning expe-

rience (MLE) to which he was exposed. Critical to the MLE process is the mediator, who facilitates the environmental stimulus and the subject. The mediator should strive to make every encounter an opportunity for growth, development and change (Feuerstein R., Feuerstein R.S., Falik e Rand, 2008).

A teacher transmits knowledge and skills on the assumption that the student is capable of learning, and that if the student does not succeed, it is the fault of the teacher. The mediator, however, is concerned with the learning process rather than the result. Feuerstein, attributing to "*the teaching quality and learning experience the main responsibility for the learner's development*" (Vanini, 2003, p. 29) raises many questions about the school's and teacher's role in student success.

The Instrumental Enrichment consists of two parts: the program and the methodology. The program consists of 14 tools, 500 sheets in total. Each tool focuses on different cognitive functions. All programs require 300 hours of application. This has been an issue because in Primary School it is difficult to add many hours to the school curriculum or remove students from the classroom. However, the ideal process would be to integrate the methodological issues into the school curriculum to build a cognitive educational curriculum or *neuro-curriculum*.

Methodological aspects include:

1. The **cognitive map**: before the lesson begins the teacher analyses the task by several criteria: content, language, cognitive functions, cognitive operations, level of complexity, level of abstraction, and level of expected efficiency.

Table 1.

The Cognitive Map

COGNITIVE MAP		
Name:	Date:	Test/Activity:
CONTENT		What is this task about?
MODALITY		What are the “languages”?
THE COGNITIVE FUNCTIONS:		
<i>input</i>		Which are cognitive functions involved in this task?
<i>elaboration</i>		
<i>output</i>		
THE COGNITIVE OPERATIONS		Which cognitive operations are required in this task?
LEVEL OF COMPLEXITY		What is level of complexity (elements number, colours, tables, graphs... on the page)?
LEVELS OF ABSTRACTION		Is this a concrete or abstract task? What is the level of abstraction?
LEVEL OF EFFICIENCY		What is the level of performance that I expect from pupils?

2. The **lesson plan**: in stages four and seven the children work individually. In all other stages the teacher and the children work together to identify the elements and objectives of the task and they discuss strategies to solve the task

This part is a spoken lesson. At the end of the task the teacher helps the children to generalize what they have learned in other situations.

Table 2.
The Lesson Plan

LESSON PLAN
1. Overview of observation task
2. Identification and precise definition of objectives
3. Prediction for any difficulty 'and anticipation of possible strategies
4. Individual work and individualized mediation
5. Discussion, analysis of strategies, processes and errors
6. Clarifying the specific terms
7. Individual work and individualized mediation
8. New discussion on strategies, processes and errors
9. Generalisation
10. Bridging

3. The **list of cognitive functions**: this list of intellectual roles is very important for monitoring children's cognitive progress.

Table 3.

The list of cognitive functions for teacher

INPUT	ELABORATION	OUTPUT
Clear perception	Accurate definition of the problem	Using clear and precise language
Systematic exploration	Selection of relevant cues	Thinking things through before responding
Precise and accurate labelling	Internalization of information	Waiting before responding
Well-developed orientation in time and space	Planning behaviour	Staying calm
Conservation of constancies	Broad mental field-remembering	Precision and accuracy in communicating data and information
Capacity to consider more than one source of information	Recognizing and understanding relationships	Clear visual transport
Need for precision, accuracy and completeness in data gathering	Spontaneous comparative behaviour	Adequate verbal tools
	Categorizing	Projection of virtual relationship
	Inferential-hypothetical thinking	
	Using logic to arrive at and defend conclusion	
	Spontaneous summative behaviour	
	Adequate verbal tools	

(Feuerstein R., Feuerstein R.S., Falik e Rand, 2008)

In my research I created an easier list of cognitive functions for the children to allow them to self-monitor their cognitive progress.

Table 4.

The list of cognitive functions for students

I LOOK THE TASK	I THINK THE TASK	I DO THE TASK
Attention and concentration	To define the problem	To communicate clearly
Staying calm	To identify important data	Be accurate
To observe	To expand mind's space	To control movements
To listen	To compare	To overcome block situations
To read	To reason	Be sure of themselves
To understand what I observe, listen and read	To plan	
To specifically name	To "imagine vision"	
Orientation in space and in time	Be sure that the answer is right	
	To predict consequences	
	To communicate the need for help	
	To find the key concepts	

(Vedovelli, 2014)

4. The **parameters of learning mediation**: The teacher has to use this intercession during the lesson to promote learning. Main mediations are: intentionality, mediation of transcendence and of meaning. Other mediations are linked to occasions that occur during the lesson.

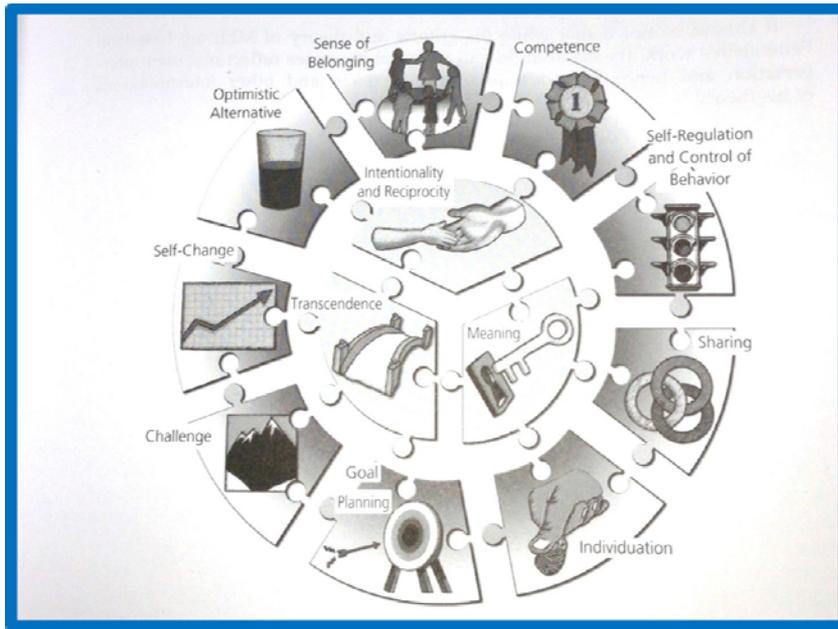


Figure 1. The mediation criteria (Mentis, M., Dunn-Bernstein, M. & Mentis, M., 2008)

Criticism

The principal criticism of Feuerstein's method lies in the insufficient scientific evidence about the effects on school performance (Bradley, 1983; Moseley et al., 2005), which makes very difficult to predict the transfer effects. The majority of criticism has focused precisely on this point (Campione & Brown, 1987; Bransford, DelClos, Vy, Burns & Hasselbring, 1987; Loarer, 1998; Loarer, Chartier, Huteau & Lautrey, 1995).

This research aims to contribute to the question of the transfer process and we are looking at how IE promote the academic success.

Romney and Samuels (2001) conducted a meta-analysis about the results obtained from controlled studies (in English) on the program before 2000. After the initial year of intervention, academic performance results showed some improvement, but many were modest and in some cases inconsistent.

The research shows that the process has the ability to improve more than the behaviour, but that are not transferred in the school environment. This result reinforces observations identified by other researchers. For example, Loarer, Chartier, Huteau and Lautrey (1995) have shared: "*Des effets [...] ont été obtenus sur certains test d'intelligence, mais pas ou tres peu sur les épreuves de personnalité, et il n'a pas non plus obtenu de transferts consistants aux résultats scolaires*" (p. 168).

This study merges the hypotheses of Jensen and Singer (1987) and Büchel (2007). According to Jensen and Singer transfer problems may be impacted by a lack of coordination between the school curriculum and the IE. The child's effective functioning requires both cognitive assistance and skills on which they can be applied. The acquisition process alone will not impact cognitive function, but if a student does not receive material on which he can enhance his learning efforts with IE, no progress is likely to be made.

According to Büchel, attempting to intervene with a learning issue can take a long time. However, any cognitive program must understand that educational institutions cannot easily provide 300 hours teaching to apply the program. The problem might be different if the program is applied as a preventive measure. The school should introduce metacognitive elements and include the concept of "teach how to learn" in a systematic way during the school year.

We believe that integrating these principles to the curriculum will help to overcome the dichotomy between "content-cognitive ability" and the transition from an instructive education to a formative education. Feuerstein's educational tools, such as the lesson plan, the cognitive map, the list of cognitive functions and criteria for mediation, in the hands of a mediator, can promote continuous analysis of a pupil's abilities and his potential. Then schools can conduct an analysis of the knowledge and skills acquired and track the transfer of cognitive skills to the areas of academic content.

Research study

Goals

The goal of this research study was to determine the Instrumental Enrichment's strengths and weaknesses in teaching pupils of the Primary School. In particular, we investigated the following aspects of learning:

- whether and to what extent Feuerstein's educational tools can be integrated into the school curriculum and significantly affect pupils' performance and the quality of teachers' learning mediation;
- the extent to which the quality of teachers' learning mediation affects academic performance.

Hypothesis

The assumption of this research is that Feuerstein's program does not positively influence academic performance if it is not integrated into the school curriculum.

It is thereby assumed that if the Feuerstein principles of mediated learning are applied to school activities, a *neuro-curriculum* can be built, resulting in a significant improvement in academic performance.

Vertical functions are specialized functions, are expressed in well-defined domains, are very sensitive to learning, change dramatically during the course of development, and are visible because they are associated with performance. In contrast, transversal functions are not specialized functions, are not domain-specific, change slowly, and are not visible because their role cannot be analysed separately from performance. Vertical cognitive functions are also called "skills", and can correlate with well-defined areas such as motor skills, language, graphic-expression skills, reading, writing, and arithmetic. Transversal functions are "invisible", but are essential to cognitive activity and are inextricably linked to the task. These functions include recognition, categorization, selection, planning, decision-making, representation, and control (Cornoldi, 1999).

The goal of this research study was to determine if application of Feuerstein's educational mediation principles and tools to the school curriculum facilitates the full integration of vertical and transversal cognitive functions,

thereby promoting school success and the student's full academic development.

Method

Participants

This research study involved four fourth grade classes in Primary School over the course of two school years (2013-2014 & 2014-2015). Specifically, 82 students, 4 teachers/mediator IE, and an IE mediator outside the school context were included.

Participant selection

The Authorized Feuerstein Centre from Sardinia provided a list of teachers trained in IE from the province of Sassari. From this list, we extrapolated teachers who worked with the third grade class. Then, six classes were selected where one teacher was trained on the Feuerstein method, but only five teachers agreed to participate in this study. Since we valued keeping homogeneity of school performance and quality of mediation by pre-test, one class was eliminated. Table 5 shows the tests results of the pre-test given in May 2013 regarding reading comprehension, listening comprehension, writing, numeracy, reasoning, prerequisite study skills, metacognitive study skills, and praxis skills.

Table 5.

Pre-test of basic and transversal skills

		N	Mean	Std. Deviation
Reading comprehension	Class group 1	19	8.32	1.701
	Class group 2	21	8.00	1.975
	Class group 3	16	7.56	2.476
	Class group 4	24	8.29	2.074
	Class group 5	18	8.61	1.501
Listening comprehension	Class group 1	19	8.89	1.595
	Class group 2	21	9.33	1.354
	Class group 3	16	9.13	1.586
	Class group 4	24	9.29	1.488
	Class group 5	19	9.53	1.577
Writing	Class group 1	19	1.63	.496
	Class group 2	21	1.52	.680
	Class group 3	16	*1.44	.512
	Class group 4	24	1.96	.690
	Class group e 5	18	*2.00	.333
Numeracy	Class group 1	18	17.50	2.834
	Class group 2	21	18.29	2.261
	Class group 3	16	17.38	3.423
	Class group 4	24	18.17	1.903
	Class group 5	18	19.11	1.491
Reasoning	Class group 1	18	20.28	4.322
	Class group 2	21	20.71	4.244
	Class group 3	18	22.44	4.693
	Class group 4	22	20.45	6.231
	Class group 5	18	21.89	2.988
Prerequisites study skills	Class group 1	19	8.42	2.411
	Class group 2	21	9.24	2.256
	Class group 3	16	*7.69	2.915
	Class group 4	24	9.08	2.302
	Class group 5	18	*10.22	2.074

Metacognitive study skills	Class group 1	19	3.84	1.068
	Class group 2	21	3.43	1.660
	Class group 3	16	3.06	1.289
	Class group 4	24	3.79	1.215
	Class group 5	18	3.56	1.199
		18	3.56	1.199
Praxis skills	Class group 1	19	8.00	2.544
	Class group 2	21	6.62	2.872
	Class group 3	16	7.11	3.445
	Class group 4	24	6.73	3.467
	Class group 5	18	7.33	2.086
		18	7.33	2.086

The statistical analysis showed a significant difference between the Class group 3 and Class group 4 relative to the prerequisite study skills test (ANOVA: $F(3,4) = 8.684$, $p = 0.21$). For the writing and praxis tests, a non-parametric test was used for different independent samples, and the Kruskal-Wallis H test was used to determine the difference in independent samples drawn from the same population. The analyses revealed a significant difference in the writing test results between the groups tested (Kruskal-Wallis H Test: Chi-square = 14.685, $df = 4$, $p = 0.005$). The means reported in Table 1 show that Class group 5 reported the highest score. It repeated the text excluding this group from the origin school variable (Kruskal-Wallis H Test: Chi-square = 7.731, $df = 3$, $p = 0.052$). The results indicate that the Class groups 1, 2, 3, and 4 belong to the same population regarding the writing and praxis tests, even if the writing test was placed very close to the confidence level.

Table 6 shows the results of the metacognitive, motivational, and socio-emotional scores awarded by teachers in the observation grid.

Table 6.

Pre-test of metacognitive, motivational, and socio-emotional attitudes

	Class group 1		Class group 2		Class group 3		Class group 4		Class group 5	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
	Interp. relations.	10.37	1.422	9.86	2.393	8.94	2.711	9.40	1.555	9.45
Respect	9.63	2.338	8.76	2.965	8.50	2.956	9.00	1.803	8.35	2.390
Adaptability	9.53	1.349	9.95	1.884	9.33	2.544	9.76	1.091	9.95	.887
Participation	*9.32	2.358	8.76	2.791	8.44	3.148	8.00	2.217	*6.45	1.986
Responsibility	9.89	2.052	8.67	2.671	8.83	2.915	9.16	2.035	8.30	2.203
Engagement	9.63	2.499	9.43	2.271	8.22	3.209	9.16	1.930	8.95	1.877
Attention	9.42	2.589	8.90	2.625	8.67	3.029	8.40	2.533	8.15	2.059
Organization	9.68	2.689	9.10	2.488	8.17	3.294	8.96	2.245	8.30	1.867
Autonomy	9.00	2.749	8.95	2.312	8.67	2.787	8.76	1.393	7.35	1.496
Motivation	9.63	2.060	8.67	2.033	8.67	2.590	8.64	1.800	8.55	1.432
Control	*9.79	1.932	9.10	2.488	8.67	3.199	8.84	2.192	*7.10	1.071

For these variables, the Kruskal-Wallis H test was applied for different independent samples. The statistical analysis revealed a significant difference between Class groups 1 and 5 with respect to the participation variables (Kruskal-Wallis H test: Chi-square = 13,535, $df = 4$, $p = 0.009$) and control variables (Kruskal-Wallis H test: Chi-square = 16,068, $df = 4$, $p = 0.003$). Even in this case, we repeated the test excluding the group class 5 and we have verified that the class groups 1, 2, 3 and 4 belong to the same population with respect to the student's metacognitive, motivational and socio-emotional attitudes.

Given these results by ANOVA and the Kruskal-Wallis H test, we decided to exclude the Class group 5 from the study, and to include the remaining four classes. There were no significant differences, however, in the quality of teachers' learning mediation. The role attribution to groups, experimental or comparison, was not random. In fact, only two class groups accepted the treatment, and the remaining two assumed the role of comparison groups. The pairing between experimental and control groups, however, has been attributed to random distribution.

Procedure

This research study fits into the quasi-experiment typology. The factorial design provided four independent groups corresponding to four classes, two experimental and two comparison. The two experimental groups were subjected to two different types of treatment, as shown in Table 7. The two comparison groups followed the conventional curriculum.

Table 7.
Design factor between independent groups

GROUPS	TREATMENT 1	TREATMENT 2
EG 1: 24 students	3 hours of IE weekly substitute for 3 hours curriculum	Principles and tools of learning mediation integrated into 13 curricular activities in a year
EG 2: 20 students		Principles and tools of learning mediation integrated into 13 curricular activities in a year
CG 3: 20 students	Conventional curriculum	
CG 4: 18 students	Conventional curriculum	

EG 1, submitted to the Instrumental Enrichment Program for a total of about 70 hours during the first year, worked with the following the first-level tools:

- Organization of dots
- Analytic perception
- Illustrations
- From Empathy to Action

The instruments were chosen in agreement with the classroom teachers, taking into account the annual program that the students need. In particular, teachers chose to strengthen some specific cognitive functions such as:

- Systematic exploration
- Need for precision, accuracy and completeness in data gathering
- Planning behaviour
- Inferential-hypothetical thinking
- Categorizing
- Adequate verbal tools

This program was administered by the author, who has served as a Feuerstein mediator since 2004. The classroom teachers, however, formed at the IE, and have applied the principles and tools of mediation of learning in 13 curricular activities during the first year. They were guided and supervised every 15 days. In particular, they were supported in the following tasks:

- Construction of educational units in accordance with the Cognitive Map principles;
- Lesson management according to the scheme developed by Feuerstein;
- Analysis of students' deficient cognitive functions;
- Application of the learning mediation criteria in the educational relationship.

The teachers were monitored through both classroom observations and video recordings. The four class groups involved in the research study were subjected to post-testing at the end of the first and second school years.

Table 8.
Assessment in interrupted time series

	Pre-test	Treatment (1° school year)	Post-test	Treatment (2° school year)	Post-test
EG 1	O1	X1	O2	X1	O3
EG 2	O1	X2	O2	X2	O3
CG 3	O1		O2		O3
CG 4	O1		O2		O3

Assessment tools

Three assessment tools were used:

1. Q1 VATA: an assessment battery by the MT GROUP (De Beni, Zamperlin, Friso, Molin, Poli e Vocetti, 2005), used to explore basic and cross skills, including reading comprehension, listening comprehension, writing, study skills, reasoning, numeracy, and praxic skills. It also includes an observation grid to assess metacognitive, motivational, and socio-emotional attitudes.
2. ASSESSMENT QUALITY OF LEARNING MEDIATION by Carol Lidz (Lidz, 1991) adapted to the group class. The Mediated Learning Experience (MLE) Assessment Scale by Carol Lidz is provides a tool to assess the mediation degree and quality that characterizes the interactions between a mediator and a child. It is used for children aged 2 to 5 years, but is potentially adaptable to a wider age range. It was developed to meet various needs:
 - to consider the multiple factors that occur within teaching and parenting relationships that can affect a child's cognitive development;
 - to monitor the progress and to evaluate the effectiveness of educational intervention;
 - to develop a profile of mediators' strengths and weaknesses.

This scale is intended to provide a behaviour assessment of mediators that may be relevant for a child's cognitive development.

Table 9.
Assessment quality of learning mediation

MEDIATION	SCORE				NOTE
Intentionality and reciprocity	0	1	2	3	
Mediation of meaning	0	1	2	3	
Mediation of transcendence	0	1	2	3	
Sharing child's experiences	0	1	2	3	
Sharing teacher's experiences	0	1	2	3	
Competence (regulation of the task)	0	1	2	3	
Competence (lode/encouragement)	0	1	2	3	
Competence (challenge)	0	1	2	3	
Psychological difference between child and mediator	0	1	2	3	
Psychological difference between subjects	0	1	2	3	
Answer to child's needs	0	1	2	3	
Emotional involvement	0	1	2	3	
Change	0	1	2	3	
Regulation and control of behaviour	0	1	2	3	

0 = no mediation; 1 = inconstant mediation; 2 = constant mediation
3 = constant mediation with elaboration

3. FOCUS GROUP: this will be proposed at the end of the second year treatment, involving, at different times, the people directly and indirectly involved in research, such as students, teachers, and parents.

Results

Does Feuerstein's methodology, when integrated into the school curriculum, have a significant impact on students' academic performance and on the quality of teachers' learning mediation?

We used different statistical analyses for parametric variables and non-parametric variables: for parametric variables, the *t-test* was used and for nonparametric variables, the *Mann Whitney test* was used. The analysis was performed for all tests in order to verify if there were significant differences between experimental and control groups. The data analysis collected at the end of the first year is still in progress; therefore, we only have partial results at this time.

This study compared EG 1 that used two treatments, with CG 3 that used the conventional curriculum as parametric variables, including reading comprehension, listening comprehension, numeracy, reasoning, prerequisite study skills, metacognitive study skills, and study skill performance. There were no significant differences between the two groups (fig. 2).

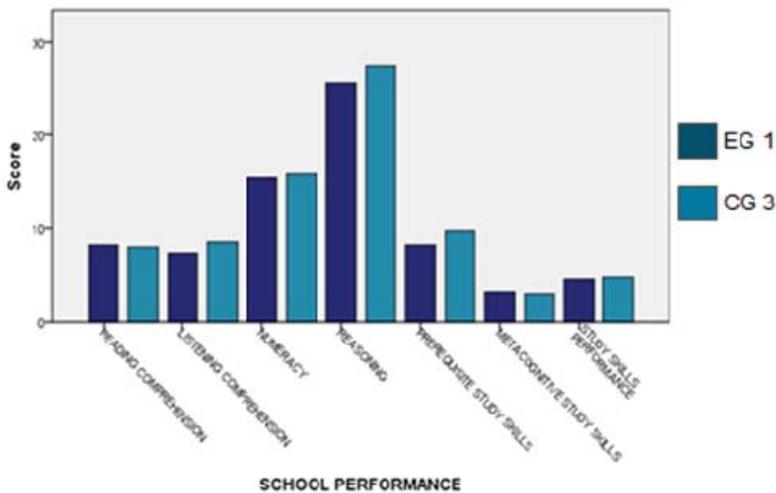


Figure 2. Comparison between EG1 and EG3

Similar results were obtained for EG 2 and CG4. There were no significant differences between the two groups (fig. 3).

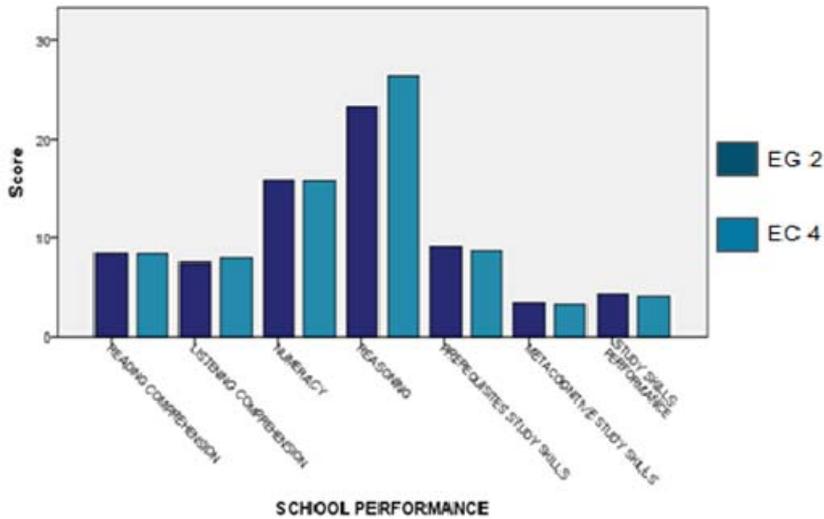


Figure 3. Comparison between EG2 and CG4

The most interesting result was the assessment of teachers' mediation quality. It compared teachers from EG 1 with teachers from CG 3. Teachers in EG 1 had the highest score in five mediations, whereas teachers in the control group had the highest score in only one mediation (fig. 4).

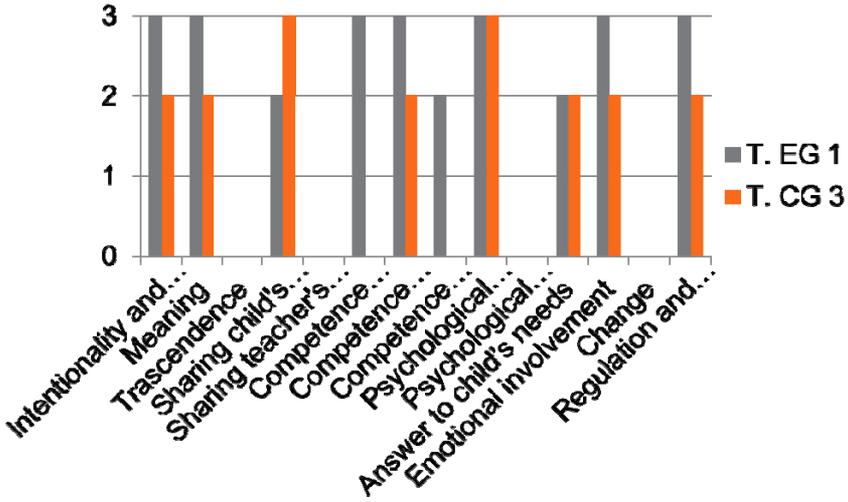


Figure 4. Quality of teachers' mediation

There were significant differences between teachers from EG 2 and from CG 4. Specifically, teachers in EG 2 had the highest score in more mediations (fig. 5).

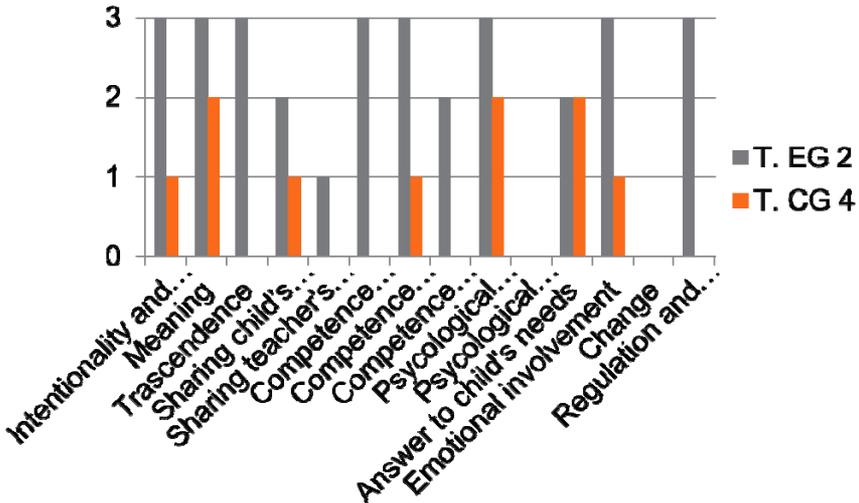


Figure 5. Quality of teachers' mediation

These results, although incomplete, showed that the quality of teachers' mediation improved in the two EG, but academic performance did not improve.

Conclusions

This research project aimed to integrate a cognitive education program; namely, the Feuerstein method, in the Primary School curriculum, and to measure the effects on students' learning and teaching quality. The main results that we expected to see were an improvement in students' school performance and in the quality of teachers' learning mediation.

The first statistical analysis conducted on the data collected in the first year did not show a significant difference in students' performance between the experimental and control groups. In contrast, we observed very interesting results regarding the quality of teachers' learning mediation. At the end of the first year, the teachers in the experimental group had higher scores than those in the control group in many mediations. This shows that it is necessary to potentiate the students' treatment.

Regardless of the results "*...cannot deny that the approach Feuerstein include declarations simple and understandable that allows the transfer of knowledge through concrete pedagogical acts*" (Büchel, 2007). Using the principles and tools of Feuerstein's method, we experienced the development of a *neuro-curriculum* in which students can "shop" while they learn, can monitor their improvement, and with the teacher's guidance, can automate effective cognitive paths.

The Feuerstein's theoretical and didactic proposal is placed in the complex society horizon. The educational tools born of his educational experience responding to the training needs of the information and knowledge society: *to teach how to learn*. We hope that the results of this and other research studies open the possibility of profoundly rethinking the curricula and teaching methods in all school grades.

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