Enhancement of thinking skills: Effects of two intervention methods

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A B S T R A C T

Three studies were carried out with Compulsory Secondary Education students to verify the effectiveness of two intervention methods—the infusion method (IM) and the instrumental enrichment program (IEP)—to enhance thinking skills, creativity, behavioral self-regulation, and academic achievement. Study 1 (N = 118) was conducted in order to create the IM, an instruction method designed to teach these skills along with the syllabus content, and to compare its effects with the conventional method (CM). In Study 2 (N = 176), the effects of the IM, the IEP, and the CM were compared in the same variables. In Study 3 (N = 168, using the same subjects as in Study 2), the effects of the IM and the IEP were analyzed to determine whether they were maintained or they increased with time. The results showed that greater changes were obtained with the IM than with the IEP in all the criterial variables and that the effects attained in Study 2, in addition to being significant, persisted at least 1 year after completing the intervention. Relevant scientific and educational implications are drawn from the studies.

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1. Introduction

Enhancement of thinking skills—reasoning, creativity, decision making and problem solving—is a difficult task, but not impossible. Research carried out in recent decades has shown that it is possible to teach people how to think; that is, significant changes in a human being's cognitive functioning can be achieved, and that these changes persist, in some cases, after completing the intervention (Baron & Sternberg, 1987; Herrnstein, Nickerson, Sanchez, & Swets, 1986; Jepson, Krantz, & Nisbett, 1993; Nisbett, Fong, Lehman, & Cheng, 1987; Perkins & Grotzer, 1997; Swartz & Parks, 1994). The problem is that most interventions do not achieve transfer of the skills acquired during the instruction period to other situations in- and outside the school. According to Ritchhart and Perkins (2005), this is the most important issue when teaching to think. This investigation was designed to better understand these issues and with the aim of achieving some effect in students' reasoning and creativity that would persist longer than the instruction period and would transfer to other educational settings.

When mentioning improving reasoning, the authors almost always refer to inductive reasoning, the most extensively studied process in cognition (Csapó, 1997). Classification, analysis, synthesis, analogy, discovering rules, and matrix organi-
zation are noteworthy among the identified micro-processes of induction (Büchel & Scharnhorst, 1993; Goldman & Pellegrino, 1984; Sternberg & Gardner, 1983). According to Kluver (1998), all the items that measure inductive reasoning use comparison, as this micro-process is the basis with which similarities and differences in attributes and relations between objects and situations are identified.

Creativity, which is multidimensional, is considered a process of searching for, combining, and assessing information (Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991; Torrance, 1988) that produces something new and useful (Sheskin, 1995). Creative people are flexible, persistent, and adaptive (Amabile, 1987; Guilford, 1950), and creativity occurs in educational and socio-cultural settings that either stimulate or inhibit and evaluate the process (Amabile, 1996). Creativity is by nature modifiable, as people can learn to develop the four characteristics that determine it: flexibility (producing many ideas), fluidity (of various characteristics), originality (new ideas), and elaboration (having many details). It seems that unless they are creative, students are not sufficiently prepared to achieve all the learning goals (Cropley & Urban, 2000; Runco & Sakamoto, 1999).

Transfer, learning something in one situation and applying it subsequently to another situation, is a complex cognitive task. Its interpretation calls for the questions: What? Where to? How? “What?” refers to what is transferred: skills, knowledge, strategies, and behaviors. “Where to?” refers to the distance between what is learned and the new situation. And “how?” is still an unknown. Research suggests several ways transfer may occur: (a) emphasizing the similarities of situations; (b) frequently practicing what was learned in different situations; (c) applying general principles to specific situations; (d) modeling concrete cases of transfer, and (e) relating contents and life events.

Brainerd (1975) operationalized transfer, according to a criterion of conceptual proximity, at three levels: near–near, when the intervention and posttest exercises are identical or almost identical; near–far, when the posttest tasks require processes that are similar to those practiced during the intervention, but the stimuli are different, and far–far, when the posttest tasks are very different from the intervention both in material and in cognitive processes. This last level is considered the most appropriate to evaluate a change in cognitive structure and the effectiveness of the intervention (Tomic & Kingma, 1998).

Research and educational experience of enhancement of thinking skills show that it is very difficult to achieve this unless, in addition to teaching these skills, a key metaprocess is stimulated: metacognition (Tomic & Klauer, 1996). According to Brown (1987), there are three essential aspects to metacognition: (a) awareness of one’s own mental processes, knowledge, beliefs and motivations; that is, for example, to be aware that one is performing the mental operation of comparing concepts, or that one is in a mental state of sadness; (b) declarative and procedural knowledge of thinking skills and their relations, and (c) self-regulation of thinking, motivation, and behavior, in order to organize one’s plans before initiating an activity, to adjust one’s actions while performing such plans, and to review the results achieved after completing the task. This metacognitive process includes a sequence of decisions made in order to distribute the effort, attention, time, etc. among the various moments of one or more tasks (Schunk & Zimmerman, 1998).

Learning to think skillfully is an efficient way to achieve many goals, but it is also an end to itself: the true goal of education (Csapó, 1997). However, this great challenge is not achieved spontaneously but rather with conscious, programmed, continuous, and evaluative interventions, which, unfortunately, is far removed from the normal classroom environment. Therefore, it is necessary to investigate which strategy can be the most helpful effect students to think more and to think more skillfully.

I.1. Intervention methods

Cognitive psychology in general and the critical thought movement in particular study intervention methods to determine which could be the most appropriate and efficient to achieve significant, generalizable, and permanent changes in thinking skills (Perkins & Grotzer, 1997; Resnick, 1987). For this purpose, two modalities have been basically employed: specific programs and infusion methods.

A variety of programs are adapted to all stages of the educational system and to students' various needs (Nickerson, Perkins, & Smith, 1985). Their defenders state that, just as mathematics and history are taught in separate courses, it makes sense to teach thinking processes. The most widely used programs in Spain are: Odyssey (Herrnstein et al., 1986), Philosophy for Children (Lipman, Sharp, & Oscanyan, 1980), Practical Intelligence at School (Williams et al., 1996), and the instrumental enrichment program (Feuerstein, Rand, Hoffman, & Miller, 1980). These programs have received diverse appraisal, going from a rather pessimistic opinion (Herrnstein & Murray, 1994) to a fairly optimistic one (Feuerstein et al., 1981). One could say, with caution, that administration of these programs shows some improvement in cognitive functioning, measured mainly with intelligence tests, and that the positive impact on IQ is approximately one half of a standard deviation. For a more complete review of these programs, readers can consult Adley & Shaper (1994), Nickerson et al. (1985), Perkins & Grotzer (1997), and Segal, Chipman, & Glaser (1985).

The second intervention strategy is the infusion methods, or direct, explicit, interactive, and parallel teaching of thinking skills along with the syllabus content, using the instruction time for both of these goals. These methods are based on the principle that academic study offers many opportunities to practice mental operations; this way, the syllabus becomes an ideal way to achieve these goals (Gaskins & Elliot, 1991; Perkins, Goodrich, Tishman, & Mirman-Owen, 1994; Swartz & Parks, 1994; Tishman, Perkins, & Jay, 1995). The infusion methods have the advantage over specific programs and over the conventional teaching method in that it promotes more transfer, both of the processes practiced and of the information acquired.
There is still no clear answer to the question of which is the most appropriate intervention method: whether one of the programs or one of the infusion methods. It is therefore necessary to continue to study the efficacy of each intervention modality, either independently or by contrasting them in one study.

It is very important for students to finish Compulsory Secondary Education knowing how to think because, as of this educational stage, they must process a lot of information, regulate their learning, and apply what they have learned to many situations. Therefore, considering the above introductory comments and the bibliography (especially Swartz & Parks, 1994, and Wallace & Adams, 1993), we performed three studies. In the first one, we designed, administered, and evaluated an infusion method; in the second one, we compared the efficacy of the infusion method from the first study to the instrumental enrichment program; and in the third study, we determined whether the effects of the intervention of the second study persisted 1 year after completing the intervention.

2. Study 1: Effect of an infusion method on thinking skills

The chief goal of this study was to develop, implement, and evaluate an infusion method to stimulate thinking skills through the syllabus contents of Science, Language, Mathematics, and Social Sciences. The main question was to determine whether, by using enriched teaching as the working method in the classroom while teaching the academic course syllabus materials, thinking skills—comparison, classification, analysis, synthesis, sequencing, interpreting causes, predicting effects and analogic reasoning—creativity, and behavioral self-regulation can be taught at the same time, thus enhancing academic achievement. In this study, the experimental group teachers taught the syllabus content using the IM, which they learned for this investigation. In contrast, the teachers of the control group taught these same subjects as they always had, in the conventional way. These methods are described in more detail below.

The general hypothesis of the study was that, in comparison with the control group students, the experimental group students would score higher in the instruments that measure thinking skills, creativity, self-regulation, and academic achievement.

2.1. Method

2.1.1. Participants

There were 118 participants (62 girls, and 56 boys, mean age 13.75 years old, S.D. = .89) from the second course of Compulsory Secondary Education, registered in the two public centers that were accessible to the investigators at that time. The centers were assigned randomly either to the experimental group (EG, n = 57) or to the control group (CG, n = 61). There were two classes (from one center) in the EG and two classes (from the other center) in the CG. According to the teachers’ reports, the students’ general academic level was low, and the parents’ economical level was estimated to be medium-low, on the basis of the location of the educational centers and other data about the families, although this variable was not quantified. The centers were not for students with special needs, giftedness, or in need of remediation.

2.1.2. Assessment instruments

2.1.2.1. Cattell Intelligence Test, Scale 2 (Cattell & Cattell, 1973). This test evaluates general mental capacity in subjects between 8 and 15 years old. It has 46 items that require performing the processes of comparison, analysis, synthesis, classification, and seriation. We selected this test because it has traditionally been considered a good instrument to measure inductive reasoning and has been used in studies related to enhancement of thinking skills (Büchel & Scharnhorst, 1993; Sternberg, 1977). In our study, the test had a reliability index of $\alpha = .81$ (Cronbach’s alpha).

2.1.2.2. Differential Aptitudes Test, DAT-5 Level 1 (Bennett, Seahirem, & Wesman, 1992). Only three tests from this battery were used: Verbal Reasoning (VR), Numeric Reasoning (NR), and Abstract Reasoning (AR). Each one of these tests has 40 items. The VR test evaluates the capacity to apply the inductive reasoning processes of analogy, comparison, discrimination, similarity, complementing, analysis, and synthesis to verbally formulated questions. The NR test evaluates these same processes with mathematical contents, and the AR test, with figures. In our study, we obtained reliability indexes of, respectively, $\alpha = .79$, $\alpha = .82$, and $\alpha = .80$ for these tests (Cronbach’s alpha).

2.1.2.3. Psychopedagogical Battery “Evaluate-8” (García Vidal, González Manjón, & García Pérez, 2002). This battery comprises cognitive tests (inductive, deductive, and spatial reasoning), and instrumental, affective, and behavioral tests. In this study, only the inductive (50 items) and deductive reasoning (23 items) tests were employed. The former evaluates the capacity to identify categories, solve verbal and figurative analogies, and discover laws that organize series. The latter evaluates the capacity to analyze deductive propositions. In our study, we obtained reliability indexes (Cronbach’s alpha) of .82 and .79, respectively, for inductive and deductive reasoning.

2.1.2.4. Creative Intelligence Test—CREA (Corbalán Berná et al., 2003). This test is a cognitive measurement of creativity by means of the respondent’s generation of questions about some graphic material. The test provides a global score and has
high correlations with other creativity tests such as, for example, the Guilford creative battery ($\alpha = .81$). In our study, we obtained a Cronbach’s alpha value of $\alpha = .78$.

2.1.2.5. Learning Strategies Scales—ACRA (subscale IV). This subscale assesses the use that students make of the metacognitive strategies (Román & Gallego, 1994). It contains 35 items about the metacognitive knowledge and about strategies of self-regulation—planning, control and evaluation—which facilitate and support the processing and the comprehension of the information. Responses are rated on a 5-point Likert-type scale ranging from no. 1 (never or seldom) to no. 5 (always or almost always). Two sample items of this scale are: (a) “I mentally plan the strategies which I think will be efficient to 'learn' every kind of subject I have to study”, and (b) “At the end of a test, I check whether the strategies I used were suitable to remember the acquired information”. The reliability index alpha of the scale in our sample was $\alpha = .75$ (Cronbach’s alpha).

2.1.2.6. Academic achievement tests (A and B). These tests measure students’ basic knowledge in the areas of Sciences, Language, Mathematics, and Social Sciences. Each test had 80 items, 20 for each subject matter. Test A (pretest) was created according to the currently established Spanish norms to measure students’ academic achievement upon completion of the first course of Compulsory Secondary Education. Test B (posttest) had the same number of items and structure as Test A, but it covered the contents of the second course of Compulsory Secondary Education. Both tests were created by the teachers of the CG, and were also used by the teachers of the EG. The obtained reliability indexes were (Cronbach’s alpha) of $\alpha = .80$ and $\alpha = .78$, respectively, for Test A and Test B.

Except for the achievement tests, none of the items of the above mentioned tests was the target of specific training. This should allow us to evaluate the level of transfer achieved.

2.1.3. Instruction materials

The instruction materials were in the form of a theoretical/practical booklet for teachers and students. The booklet presented the following contents related to the intervention: (a) operational definition and graphic organizer of each skill to be taught (see Swartz & Parks, 1994); (b) information about the activities to be carried out in the eight stages of the method: organize, identify, generate, decide, verify, assess, communicate, and learn (Sanz de Acedo Lizarraga & Sanz de Acedo Baquedano, 2005; Wallace & Adams, 1993) (see Appendix A), and (c) a table of the skills to be exercised in each didactic unit (contents related to a specific topic of the syllabus-content), according to the textbooks: Sciences (Barrio Gómez de Agüero, Bermúdez Meneses, Faure López, & Gómez Esteban, 2003), Language (Castán, Fernández, & Laborda, 2003), Mathematics (Yábar, Vallés, & Margalef, 2002), and Social Sciences (Sada, Santos, Àlcàzar Vinyals, Espino, & Etxebarria, 2003). Both the EG and the CG used the same textbooks.

2.1.4. Design

The work plan we followed corresponds to a quasi-experimental design with two measures: pre- and posttest. The independent variable was the infusion method administered to the EG and the dependent variables were: intelligence as measured by the Cattell test; verbal, numeric, and abstract reasoning as measured by the DAT-5 Level 1; inductive and deductive reasoning as measured by the Evaluate-8 battery; creativity as measured by the CREA; self-regulation as measured by the Subscale IV (ACRA test), and academic achievement as measured by tests A and B.

The instruments were administered by the investigators before and after the intervention, except for the academic achievement tests, which were administered by the teachers.

2.1.5. Procedure

2.1.5.1. Contacting the centers. The first step was to contact the directors and teachers of the school centers. They were informed about the goal of the investigation, its structure and content, and the training required by the teachers. The parents were also informed that a new teaching method would be employed with their children, and that, as it was a different method from that used in previous academic courses, the children would be evaluated at the beginning and at the end of the course, in order to appraise its effects.

2.1.5.2. Training the teachers. In the academic course preceding the intervention, the four EG teachers (3 women and 1 man with 10–15 years of professional experience) participated in three seminars, each one lasting 15 h. In the first seminar, thinking skills and the possibility of improving them through the syllabus content were studied. In the second seminar, the methodology to be followed was explained, using the diagram divided into the stages (grouping and organizing, identifying, generating, deciding, verifying, evaluating, communicating, and learning). In the third seminar, the textbooks were analyzed to determine the skills to be worked on in each didactic unit. The CG teachers (2 women and 2 men with 12–18 years of professional experience) also attended two seminars, each one lasting 5 h. In the first seminar, the teachers explained and discussed their teaching methods. No any particular guidance was provided. In the second seminar, they prepared the above mentioned academic achievement tests. The hours the teachers spent at the seminars were acknowledged by the educational centers and counted as part of the obligatory formation time.
2.1.5.3. Student participation.

1. **Pretest.** At this stage, all the participants were evaluated in the target variables by means of collective administration of the following instruments, in three sessions: (a) Cattell, CREA, Evaluate-8, and RV; (b) ACRA, RN, and RA, and (c) the Academic Achievement test A.

2. **Intervention.** The intervention consisted of the use of the infusion method in the EG and the conventional method in the CG for one academic course (September to June).

   **Infusion method.** It consisted of teaching thinking skills (comparison, classification, analysis, synthesis, seriation, interpreting causes, predicting effects, and analogical reasoning), creativity, and self-regulation of learning simultaneously along with the syllabus content of Sciences, Language, Mathematics, and Social Sciences. Each skill was explicitly practiced at least once in each one of these subjects.

   On the first day of class, the teachers informed the students that: (a) in the subjects of Sciences, Language, Mathematics, and Social Sciences they would be using a new method that would help them to think better about the study content; (b) the purpose of the course was twofold: particularly, to improve their thinking skills and academic achievement; (c) to achieve these goals, they should work responsibly, both individually and as a group, and (d) the method would be used in each didactic unit and the duration would be approximately three weeks (four hours per week).

   At the beginning of each unit, the teachers attempted to explain the skill, creativity, self-regulation, and transfer. They defined the **skill** analyzing the steps to be taken mentally to practice it. For example, comparison requires the following steps: (a) in what ways are animal cell and plant cell similar? Both have a cell membrane, reproduce by cell division, have a nucleus, are alive, substances to pass through their membranes, contain water, are very small, contain cytoplasm, and produce chemical energy; (b) in what ways are they different? Animal cells often have irregular shapes which continually change vs. plant cells usually have regular shapes like cubes which do not change, animals produce chemical energy by breaking down food vs. plants produce chemical energy by using sunlight, and animal cells have only a cell membrane vs. plant cells have both a cell membrane and a cell wall; (c) to what categories do the differences belong? Cell shape, energy source and structure; (d) what similarities and differences are the most significant? Structures and components relate to what cells do; cell division leads to plant and animal growth and energy users and producers; variety of functions, (e) what conclusion can be reached about the similarities and significant differences? Both animal and plant cells have structures that are good for doing the jobs required of them, plant cells have strong cell walls so that they can be stacked like bricks and their leaves can get high enough to get sunlight, while animals need to move around and get food, etc.

   Also, in each unit the teachers stimulated to students for producing new ideas mainly in the phase of the generating they should attend to list many possibilities about the topic, of various characteristics and original or unusual. For example, what options might we have for improving life of animal and plant cells?

   They interpreted self-regulation by grouping the eight stages of the method into three: before learning (organizing, identifying, generating, and deciding), while learning (verifying), and after learning (assessing, communicating, and learning from the experience) and showed how the important is each one of these moments.

   And, lastly, they stimulated **transfer:** (a) by teaching the steps of the skill in the diverse curricular contents; (b) applying the skill in- and outside of the educational environment or applying the process within the same class session or soon afterward to content similar (near transfer) and different (far transfer) from that of the initial infusion lesson. For example, compare and contrast two parallel processes in plant and animal cells, meiosis and mitosis and compare and contrast two breakfast cereals in order to decide which is a better buy and which is more nutritious, and (c) inviting the students at the end of each didactic unit to answer several questions, such as: on what aspects did I work well during this unit? Which aspects were more difficult? What should I do to improve in the next unit? How could I use what I learned in this unit in other lessons and situations?

   **Conventional method.** The CG students were taught as is customary in the Spanish educational system. This system focuses only on teaching the syllabus contents: the teachers explain the lessons, and the students study at home or perform the prescribed tasks, hardly participating in group activities because these take up too much time. The teachers subsequently evaluate the students’ academic achievement, usually requesting the mere repetition of whatever was taught. Such learning is achieved with minimum and shallow comprehension, and as a rule requires the students to memorize or retain facts (simple recall).

   During the intervention, the investigators visited the experimental group once a week as observers and, at the end of each school term, they met with the teachers to analyze certain aspects of the intervention process. The teachers’ attitude was positive from the start and, when they were informed about the goal of the study, they agreed to participate actively.

3. **Posttest.** In order to determine the effects of the intervention, upon completing it at the end of the academic course (in June), the students from both groups were evaluated by administrating the same tests (except for Academic Achievement Test B, which substituted Academic Achievement Test A) and in the same order as at pretest.
2.2. Analysis and results

To study the changes in the variables of interest in this investigation, descriptive analysis and analysis of variance (MANOVAs and ANOVAs) were conducted with the experimental and control groups, with the scores obtained at pre- and posttest, and analysis of covariance (MANCOVAs and ANCOVAs) on the scores obtained at posttest–pretest (see Table 1).

The results of the pretest MANOVA revealed statistically significant differences between the experimental and the control participants before the intervention [Wilks’ Lambda: $F(9, 108) = 3.81, p < .000, \eta^2 = .24$]; however, the results of the ANOVAs showed statistically significant differences between the same participants only in the variables numerical reasoning $F(1, 116) = 6.17, p = .05, \eta^2 = .05$, and academic achievement, $F(1, 116) = 4.94, p = .028, \eta^2 = .04$, in both cases favoring the CG. This indicates that at the beginning of the investigation, these two groups were relatively homogeneous in most of the thinking skills, creativity, self-regulation, and academic achievement.

The MANOVAs of the posttest scores revealed statistically significant differences between the experimental group and the control group in all the variables [Wilks’ Lambda: $F(9, 108) = 15.87, p < .000, \eta^2 = .57$]; likewise, the ANOVAs reached statistical significance in all the variables except for abstract reasoning; the effect sizes were low ($\eta^2 = .06$) and medium ($\eta^2 = .40$). The results in Table 1 could be valued taking into account the interpretive norms of the respective tests. Thus, for example, in the variable intelligence, the mental capacity of the EG subjects improved with the intervention, as they obtained a higher mean at posttest than at pretest ($M = 25.88, CI = 111 and 23.77, CI = 103$, for post- and pretest, respectively) (see Cattell & Cattell, 1973); and in the variable verbal reasoning, their capacity to reason analogically improved with the intervention, also obtaining a higher posttest mean than at pretest ($M = 20.91, \text{percentile} = 70$ and $M = 19.77, \text{percentile} = 55$, for post- and pretest, respectively) (see Bennett et al., 1992).

Lastly, the multivariate analysis of variance (MANCOVA), carried out with the pretest scores as covariates, confirmed statistically significant differences between students’ performance at pre- and posttest, both in the experimental group and in the control group [Wilks’ Lambda: $F(18, 448) = 12.21, p < .000, \eta^2 = .33$]. These data suggest that the infusion method had a significant effect, with a medium-low effect size. The univariate analyses of variance (ANCOVA), also using the pretest scores as covariates, were significant in all the variables. This technique allows better control of the regression of the data towards the mean and also eliminates the effect of pretest scores on posttest scores. ANCOVA divides the total variability into two components: one due to the regression, that is, the variability explained by the pretest and the group variable, and the second component, the unexplained or residual variance. Therefore, the mean square error is smaller with this technique than with ANOVA because ANOVA does not incorporate pretest scores and, consequently, the variance explained by these variables is added to the residual variance (Bonate, 2000). The results obtained reveal that the group variable is statistically significant in

<table>
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<th>Performance indicators</th>
<th>Pretest</th>
<th>Posttest</th>
<th>ANCOVA Pre-Posttest</th>
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<tr>
<td></td>
<td>EG, n = 57</td>
<td>CG, n = 61</td>
<td>ANOVA</td>
</tr>
<tr>
<td>MMF (S.D.) (S.D.) (S.D.) (S.D.)</td>
<td>23.77 (3.62)</td>
<td>23.92 (3.33)</td>
<td>.05</td>
</tr>
<tr>
<td>MMF (S.D.) (S.D.) (S.D.) (S.D.)</td>
<td>15.56 (1.32)</td>
<td>16.33 (1.95)</td>
<td>6.17</td>
</tr>
<tr>
<td>Verbal R1 (2.13) (2.18)</td>
<td>19.77 (2.13)</td>
<td>19.79 (2.18)</td>
<td>–</td>
</tr>
<tr>
<td>Numerical R1 (2.13) (2.18)</td>
<td>21.46 (2.13)</td>
<td>22.15 (2.18)</td>
<td>1.85</td>
</tr>
<tr>
<td>Abstract R1 (3.10) (3.74)</td>
<td>27.77 (3.10)</td>
<td>27.48 (3.74)</td>
<td>.22</td>
</tr>
<tr>
<td>Inductive R1 (1.88) (1.72)</td>
<td>12.68 (1.88)</td>
<td>13.23 (1.72)</td>
<td>2.71</td>
</tr>
<tr>
<td>Deductive R1 (1.93) (1.29)</td>
<td>12.35 (1.93)</td>
<td>12.75 (1.29)</td>
<td>1.80</td>
</tr>
<tr>
<td>Creativity (1.93) (1.29)</td>
<td>12.35 (1.93)</td>
<td>12.75 (1.29)</td>
<td>1.80</td>
</tr>
<tr>
<td>Self-regulation (3.50) (4.39)</td>
<td>95.05 (3.50)</td>
<td>95.61 (4.39)</td>
<td>.57</td>
</tr>
<tr>
<td>Academic A2 (5.68) (5.1)</td>
<td>5.49 (5.68)</td>
<td>5.74 (5.1)</td>
<td>4.94</td>
</tr>
</tbody>
</table>

R1 = reasoning; A2 = achievement.

* $p > .05$.
** $p > .01$.
*** $p > .000$. 
all cases; that is, the means of the dependent variables (posttest) in the EG (which received the infusion method of teaching) were significantly different from the means of the response variables of the CG (which was taught by the conventional method), as shown by the values of the $F$ test, its corresponding, $p$ values and the effect size (see Table 1).

Therefore, the EG students benefited from their instruction method more than the CG, because their performance was superior in all the dependent variables to the performance of the CG. The EG students significantly enhanced the stimulated thinking skills, creativity, self-regulation, and academic achievement and there was an important degree of transfer of what they had learned to the diverse reasoning tests. However, these results should be viewed with caution and it was considered appropriate to replicate the intervention with the infusion method. This task was undertaken in Study 2.

3. **Study 2: Comparison of two intervention methods in thinking skills**

The purpose of this study was to replicate the intervention carried out in Study 1 and to compare the effects of the infusion method with those of the instrumental enrichment program in the performance of tasks that require thinking skills (comparison, classification, analysis, synthesis, seriation, interpreting causes, predicting effects, and analogical reasoning), creativity, behavioral self-regulation, and academic achievement. Experimental Group 1 (EG1) was trained with the IM, Experimental Group 2 (EG2) with the IEP, and the control group (CG) with the CM.

The theoretical framework for this second investigation was the same as in Study 1, complemented with the structural cognitive modifiability theory and the IEP developed by Feuerstein et al. (1980). According to the modifiability theory, deficient cognitive functioning and poor academic achievement are due to the inadequate use of mental operations and the lack learning experiences that a good mediator can provide. The purpose of the IEP, among others, is to achieve changes in the mental processes that intervene in the act of thinking and in self-regulation of behavior. It is made up of 14 working instruments, about 500 paper-and-pencil exercises. Its contents are universal, and act as the vehicle to develop and crystallize the functional prerequisites of thinking. Each one of the instruments activates one or more cognitive operations and prepares the student to perform more complex operations. The program seems to be more effective with low intellectual level students (Rand, Tannenbaum, & Feuerstein, 1979; Sanz de Acedo Lizarraga, 1989) and, in some cases, the gains achieved have even persisted 2 years after having received the instruction (Sanz de Acedo Lizarraga, Ugarte, Iriarte, & Sanz de Acedo Baquedano, 2003). With normal students, changes in IQ and in academic achievement have sometimes been attained (Sanz de Acedo Lizarraga, 1994), but not always (Blagg, 1991).

Our working hypotheses were as follows: (a) EG1 (students who received IM) would achieve better results in thinking skills, creativity, self-regulation, and academic achievement than EG2 (students who received IEP) and CG (students who received CM), and (b) EG2 would obtain better results in thinking skills, creativity, self-regulation, and academic achievement than CG.

3.1. **Method**

3.1.1. **Participants**

Participants in this study were 176 students (92 girls and 84 boys, mean age 13.8 years, S.D. = .89) from second grade of Compulsory Secondary Education from one public center (two classes) and two private centers (four classes, two from each center) that were accessible to the investigators at that time. The public center, which comprised EG1 ($n = 55$), was the same one as in Study 1, but sample was not the same. We decided to perform the infusion method in the same center for two reasons: (a) the board of directors asked us to, and (b) this way, we could take advantage of the teachers’ prior training and experience in the infusion method. Each one of the private centers was randomly assigned either to EG2 ($n = 60$) or to the CG ($n = 61$).

According to the teachers’ observations, the students had a mean academic grade of “passed”, and sometimes lower, but they presented some deficiencies in interpreting information, in self-regulation of learning tasks, and in their behavior.

3.1.2. **Design**

The design used in this study, with the same evaluation and intervention materials as those of Study 1, was quasi-experimental, with one factor or independent variable—teaching method divided into three modalities: infusion method, instrumental enrichment program, and conventional method—and pre- and posttest measurements in all three groups. The dependent variables were the same as those in Study 1.

3.1.3. **Procedure**

3.1.3.1. **Contacting the centers.** The same steps as in Study 1 were followed.

3.1.3.2. **Training the teachers.** Before the intervention, the EG1 teachers participated in two 5-h seminars to review and learn the IM in even more detail and the concepts of thinking skills. Although they did not teach the IEP, the teachers from EG2 participated in a 5-h seminar in which was discussed this program, its goals, and the importance of transferring what is practiced in the program to the subjects of Sciences, Language, Mathematics, and Social Sciences. They were also invited to attend, as observers, the classes during the intervention and asked to up-date the two academic achievement tests (A and B) already created in Study 1. A 3-h meeting was carried out with the CG teachers to inform them about the goals of the project.
and to plan the evaluation sessions at the beginning (September) and at the end (June) of the academic course. The same textbooks were used in all three groups, and the same didactic units were taught as in Study 1. During the intervention, the investigators visited the classes of the EG1 once a week as observers and, at the end of each trimester, they met the teachers of the experimental groups to discuss: (a) in EG1, the advantages and disadvantages of the intervention and the usefulness of the materials, and (b) in EG2, the students’ reactions to the program and the transfer of the operations practiced in the IEP to the syllabus content areas.

3.1.3.3. Student participation.

1. Pretest. The three groups were evaluated with the same tests, sequences, and times as in pretest from Study 1.

2. Intervention. The infusion method and conventional method were applied using the same strategies as in Study 1. The following instruments and pages from the IEP were used: Organization (pp. 1–13, except for p. 2); Comparisons (pp. 1–15); Categorization (pp. 1–19, except for pp. 7, 8, 11, and 15); Instructions (pp. 1–18, except for 9, 11, 12, and 16); Numeric progressions (pp. 1–15, except for 8 and 12); Family relations (pp. 1–14, except for 6, 10, and 12); Temporal relations (pp. 1–15, except for 9 and 12), and Pattern design (pp. 1–18, except for 10 and 12). Thus, the students worked with 9 instruments (124 pages) during 120 h (4 h per week). This version of the IEP took into account the students’ age, the difficulty level of the pages, and the type of skill to be improved. The IEP was scheduled as an optional subject; on the advice of the direction of the educational center, all the students from the EG2 classes chose this program. Two investigators, who had a lot of experience in this program, distributed the task of administering the instruments.

3. Posttest. The students were evaluated with the same instruments as at posttest in Study 1.

3.2. Analysis and results

Although the result of the pretest MANOVA showed statistically significant differences for all the variables among the participants of the three groups of the study [Wilks’ Lambda: $F(18, 330) = 3.06$, $p < .000$, $\eta^2 = .14$], the results of the ANOVAs of each variable did not yield significant differences and therefore, they are not included in Table 2. That is, the groups were relatively homogeneous in thinking skills, creativity, self-regulation, and academic achievement.

As no significant differences were found between the groups before beginning the intervention, we decided to use MANOVA and ANOVAs to analyze the data obtained at posttest. The results of the MANOVA yielded statistically significant differences between the two experimental groups and the control group, with a medium effect size value [Wilks’ Lambda: $F(18, 330) = 3.06$, $p < .000$, $\eta^2 = .14$].

Table 2

<table>
<thead>
<tr>
<th>Performance indicators</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Post hoc comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EG1, $n = 55$</td>
<td>EG2, $n = 60$</td>
<td>CG, $n = 61$</td>
</tr>
<tr>
<td>Intelligence</td>
<td>23.89 (3.03)</td>
<td>24.00 (2.45)</td>
<td>24.49 (4.16)</td>
</tr>
<tr>
<td>Verbal R¹</td>
<td>19.52 (2.34)</td>
<td>19.17 (2.18)</td>
<td>19.10 (2.54)</td>
</tr>
<tr>
<td>Numerical R¹</td>
<td>15.44 (1.05)</td>
<td>15.65 (1.77)</td>
<td>15.31 (1.81)</td>
</tr>
<tr>
<td>Abstract R¹</td>
<td>22.17 (2.51)</td>
<td>22.30 (2.68)</td>
<td>22.00 (2.58)</td>
</tr>
<tr>
<td>Inductive R¹</td>
<td>28.91 (3.06)</td>
<td>28.40 (2.88)</td>
<td>28.05 (3.93)</td>
</tr>
<tr>
<td>Deductive R¹</td>
<td>12.24 (1.35)</td>
<td>12.42 (1.93)</td>
<td>12.00 (1.82)</td>
</tr>
<tr>
<td>Creativity</td>
<td>2.44 (2.08)</td>
<td>2.26 (1.97)</td>
<td>12.03 (2.63)</td>
</tr>
<tr>
<td>Self-regulation</td>
<td>96.35 (1.90)</td>
<td>96.26 (1.76)</td>
<td>98.26 (8.5)</td>
</tr>
<tr>
<td>Academic A²</td>
<td>5.49 (.90)</td>
<td>5.78 (.76)</td>
<td>6.99 (.85)</td>
</tr>
</tbody>
</table>

R¹ = reasoning; A² = achievement.

* $p > .05$.
** $p > .000$. 

$\eta^2$ = partial eta squared.
Lambda: $F(18, 330) = 15.58, p < .000, \eta^2 = .46$]. The results of the ANOVAs revealed statistically significant differences among the three groups in all the dependent variables (see Table 2), with effect sizes—proportion of variance explained by each variable—between $\eta^2 = .05$ for self-regulation and $\eta^2 = .45$ for academic achievement. Post hoc tests showed: (a) significant differences in intelligence, abstract, inductive, and deductive reasoning, self-regulation, and academic achievement between the experimental groups and the CG, and (b) that EG1 scored higher than EG2 in verbal and numerical reasoning, creativity, and academic achievement. We also emphasize that the performance of the EG1 in academic achievement was superior to that of the other two groups (EG1 > EG2 > CG), which seems to indicate that the infusion method has a greater impact on learning processes.

Summing up, the results obtained partially confirm: (a) our first hypothesis, as EG1 did not achieve significant differences in all the thinking skills studied in comparison to EG2, and (b) our second hypothesis, because EG2 did not obtain better results than the CG in verbal, numeric reasoning, and creativity. These intervention effects suggest that there was some degree of transfer of the learnings with the infusion method to various reasoning tasks and some transfer of the learnings with the IEP. The results of Study 2 also replicate the satisfactory data of Study 1, so it can be stated that the infusion method used in both studies is suitable to teach some cognitive skills. The intervention strategies analyzed could be ranked from most to least effective as follows: infusion method, instrumental enrichment program, and conventional method.

4. Study 3: Long-term effects of two intervention methods to enhance thinking skills

According to Tomic et al. (1993), if the effects of an intervention are to be accepted as real changes in individuals’ cognitive functioning, they should persist at least four months after completing the intervention. In this study, we wished to determine whether: (a) there were still differences between EG1, EG2, and the CG in the criterial variables, and (b) the effects of the infusion method, the instrumental enrichment program, and conventional method of Study 2 persisted or increased 1 year after having completed the intervention in each of the groups that participated in the study.

4.1. Method

4.1.1. Participants

The participants were the same members of Experimental Groups 1 and 2 and control group ($n = 53, 57$, and $n = 59$, respectively), except for a few dropouts, at the end of their third course of Compulsory Secondary Education. Their mean age was 14.5 years (S.D. = .75). As in the previous interventions, the teachers’ and students’ positive attitude contributed to being able to carry out the evaluations.

4.1.2. Assessment instruments

The following evaluation tests, described in Study 1, were employed as this study: the Cattell test (Scale 3), the Differential Aptitudes Test (DAT-5; Level 1), the Psychopedagogical Battery (Evaluate-9), the Creative Intelligence test (CREA), and the Learning Strategies Scales (ACRA-Scale IV). In this study, academic achievement was not evaluated with an instrument designed ad hoc, but instead using the average final grades achieved by the participants in the subjects of study.

4.1.3. Design

The work plan of this study was a design of the one factor, the teaching method practiced in Study 2, with three dimensions (infusion method, instrumental enrichment program, and conventional method) and one posttest measurement in all three groups. The dependent variables were: intelligence, verbal, numeric, abstract, inductive and deductive reasoning, creativity, self-regulation, and academic achievement.

4.1.4. Procedure

4.1.4.1. Contacting the centers. It had already been agreed with the directors and teachers of the centers where Study 2 was conducted that, at the end of the third course of Compulsory Secondary Education, we would proceed to administer the final tests and require the students’ average grades in Sciences, Language, Mathematics, and Social Sciences. Of the four teachers from the EG1 who participated in Study 2, only one, the mathematics teacher, was still teaching this subject to the EG1 students of the third course of Compulsory Secondary Education, and of the four EG2 teachers who participated, albeit indirectly, in Study 2, two of them, the Language and Social Sciences teachers, were still working with this group. When we asked the mathematics teacher from EG1 whether he still used the infusion method, he said that he only used some aspects of the wheel, but not systematically.

4.1.4.2. Student participation. The tests were administered in three 1.5-h sessions, in the following order: (a) the Cattell Test 3 and VR of the DAT; (b) AR and NR of the DAT, and (c) Inductive Reasoning and Deductive Reasoning from the Evaluate-9 Battery, CREA, and ACRA
Table 3
Study 3: means, standard deviations, ANOVAs, and post hoc of the experimental groups (EG1 and EG2), and control group (CG) in studied dependent variables.

<table>
<thead>
<tr>
<th>Performance indicators</th>
<th>Groups</th>
<th>Post hoc comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EG1, n = 53</td>
<td>EG2, n = 57</td>
</tr>
<tr>
<td></td>
<td>M (S.D.)</td>
<td>M (S.D.)</td>
</tr>
<tr>
<td>Intelligence</td>
<td>27.43 (2.50)</td>
<td>25.51 (2.72)</td>
</tr>
<tr>
<td>Verbal R1</td>
<td>21.91 (1.38)</td>
<td>20.47 (2.91)</td>
</tr>
<tr>
<td>Numerical R1</td>
<td>18.47 (1.56)</td>
<td>16.11 (1.83)</td>
</tr>
<tr>
<td>Abstract R1</td>
<td>25.77 (2.27)</td>
<td>24.53 (2.31)</td>
</tr>
<tr>
<td>Inductive R1</td>
<td>32.17 (2.45)</td>
<td>29.44 (2.56)</td>
</tr>
<tr>
<td>Deductive R1</td>
<td>14.62 (1.50)</td>
<td>14.30 (2.07)</td>
</tr>
<tr>
<td>Creativity</td>
<td>15.91 (1.33)</td>
<td>12.91 (1.44)</td>
</tr>
<tr>
<td>Self-regulation</td>
<td>102.42 (3.62)</td>
<td>98.86 (3.41)</td>
</tr>
<tr>
<td>Academic A2</td>
<td>7.04 (.59)</td>
<td>5.93 (.68)</td>
</tr>
</tbody>
</table>

R1 = reasoning; A2 = achievement.
* $p > .05$.
*** $p > .000$.

4.2. Analysis and results

The results of this study were analyzed taking into account the two questions that this investigation attempted to resolve: whether there were still differences between the groups and whether the effects in each group were maintained. To respond to the first question, a multivariate analysis of variance (MANOVA) and ANOVA was used and for the second, a simple analysis of variance (ANOVA) with repeated measures (posttest 2 from Study 2 and posttest 3 from Study 3).

The MANOVA carried out on the set of variables from Study 3 showed that 1 year after completing the intervention, there were statistically significant differences between the Experimental Groups 1 and 2 and the control group [Wilks’ Lambda: $F(18, 314) = 22.59$, $p < .000$, $\eta^2 = .56$]. The ANOVAs confirmed these differences in all the variables studied, and the lowest effect sizes were found in the variables self-regulation ($\eta^2 = .05$) and intelligence ($\eta^2 = .09$) and the highest ones in the variables creativity ($\eta^2 = .41$) and academic achievement ($\eta^2 = .42$). The post hoc tests revealed that: (a) the EG1 was significantly different from EG2 in intelligence, verbal, numerical, abstract, and inductive reasoning, creativity, and academic achievement, and from CG in all the variables, and (b) The EG2 was significantly different from the CG in verbal, abstract, inductive, and deductive reasoning (see Table 3).

The repeated measures ANOVAs (within-subject) on EG1 revealed that the effect of the infusion method on numerical, abstract, and inductive reasoning, creativity, and self-regulation increased 1 year after completing the intervention, that is, the students improved significantly in these variables, with the highest effect size in creativity ($\eta^2 = .61$) and the lowest in self-regulation ($\eta^2 = .21$); the remaining variables studied (intelligence, verbal and deductive reasoning, and academic achievement) showed a tendency to improve, without achieving statistical significance (see Table 4). EG2 only improved in verbal reasoning, and decreased in intelligence, and maintained the same level in numerical, abstract, inductive, and deductive reasoning, creativity, self-regulation, and academic achievement. Lastly, the CG did not achieve either significant improvements or losses in the variables studied.

From the analyses performed, it can be concluded that the intervention carried out with the infusion method was still effective one academic year later. The improvements that were achieved in Study 2 maintained, but they even increased. In contrast, the IEP maintained almost all its results of Posttest 2 and only increased significantly in verbal reasoning.

5. General discussion

In these three studies, it has been shown that: (a) the infusion method seems more effective than the instrumental enrichment program and the conventional method to enhance intelligence, verbal, numeric, abstract, inductive and deductive reasoning, creativity, self-regulation, and academic achievement in students from the second course of Spanish Compul-
Table 4
Means, standard deviations and ANOVAs of Experimental Group 1 (EG1), Experimental Group 2 (EG2), and control group (CG) at posttest 2 (posttest of Study 2) and at posttest 3 (posttest of Study 3) in studied dependent variables.

<table>
<thead>
<tr>
<th></th>
<th>Post 2–Post 3</th>
<th>Post 2–Post 3</th>
<th>Post 2–Post 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>.Eta (η²)</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>(S.D.)</td>
<td></td>
<td>(S.D.)</td>
</tr>
<tr>
<td>Intelligence</td>
<td>27.51</td>
<td>.29</td>
<td>26.73</td>
</tr>
<tr>
<td></td>
<td>(2.68)</td>
<td></td>
<td>(2.99)</td>
</tr>
<tr>
<td>Verbal R¹</td>
<td>21.87</td>
<td>.07</td>
<td>19.53</td>
</tr>
<tr>
<td></td>
<td>(1.85)</td>
<td></td>
<td>(1.64)</td>
</tr>
<tr>
<td>Numerical R¹</td>
<td>17.53</td>
<td>.36</td>
<td>16.07</td>
</tr>
<tr>
<td></td>
<td>(1.48)</td>
<td></td>
<td>(1.84)</td>
</tr>
<tr>
<td>Abstract R¹</td>
<td>24.80</td>
<td>.42</td>
<td>24.07</td>
</tr>
<tr>
<td></td>
<td>(3.00)</td>
<td></td>
<td>(1.79)</td>
</tr>
<tr>
<td>Inductive R¹</td>
<td>31.18</td>
<td>.34</td>
<td>29.87</td>
</tr>
<tr>
<td></td>
<td>(2.68)</td>
<td></td>
<td>(2.37)</td>
</tr>
<tr>
<td>Deductive R¹</td>
<td>14.55</td>
<td>.10</td>
<td>13.63</td>
</tr>
<tr>
<td></td>
<td>(1.51)</td>
<td></td>
<td>(2.05)</td>
</tr>
<tr>
<td>Creativity</td>
<td>14.65</td>
<td>.61</td>
<td>12.75</td>
</tr>
<tr>
<td></td>
<td>(2.63)</td>
<td></td>
<td>(1.79)</td>
</tr>
<tr>
<td>Self-regulation</td>
<td>100.56</td>
<td>.21</td>
<td>98.77</td>
</tr>
<tr>
<td></td>
<td>(2.53)</td>
<td></td>
<td>(4.60)</td>
</tr>
<tr>
<td>Academic A²</td>
<td>6.99</td>
<td>.05</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>(.62)</td>
<td></td>
<td>(.78)</td>
</tr>
</tbody>
</table>

R¹ = reasoning; A² = achievement.  
*p > .05.  
*** p > .000.

sory Secondary Education; (b) the changes achieved with the infusion method were not only maintained but they even increased in numerical, abstract, and inductive reasoning, in creativity, and self-regulation during the following year after their administration; (c) the instrumental enrichment program is an efficient method to stimulate the development of intelligence, abstract, inductive and deductive reasoning, and self-regulation, and (d) the effects of the instrumental enrichment program in numerical, abstract, inductive, and deductive reasoning, creativity, self-regulation, and academic achievement were maintained, in verbal reasoning were increased, and in intelligence were reduced during the following year after their administration.

These findings corroborate the statements of many authors who defend the possibility of improving thinking skills (Baron & Sternberg, 1987; Cropley & Urban, 2000; Perkins & Grotzer, 1997; Runco & Sakamoto, 1999; Swartz & Parks, 1994, among others), as well creativity (Amabile, 1996), self-regulation of behavior (Schunk & Zimmerman, 1998), and learning transfer (Pressley & Woloshyn, 1995; Tomic & Klauer, 1996). Despite persisting discrepancies about this issue, research—such as this work—contributed evidence that lead to the admission that it is possible to stimulate human being’s cognitive capacities.

It can also be said that the cognitive resources of metacognition, self-regulation, and transfer played a primary role in the improvements achieved by the experimental groups. It seems that the students should be internalized the idea of how important it is to learn to reflect on the information received, to regulate activities, and to apply what they had learned.

Regarding learning transfer, at least, we achieved near-far generalization of the skills practiced during the intervention to all the problems of the test items, which were not the target of intervention in any of the methods employed. The students from the two experimental groups displayed gains in their performance of the tasks of the intelligence test and reasoning. That is, intelligence and reasoning (chiefly inductive reasoning) share some common variance, as has been observed by Klauer (1992, 1998), among other authors. This statement lends support to the arguments of authors who believe that it is possible to improve intelligent behavior, especially if one accepts a broader view of its nature, as do these authors (Sternberg & Wagner, 1986). Moreover, the students from EG1 achieved higher academic grades, which means that the training generated a structure of transferable action that was efficient. These EG1 gains could be due to the fact that the infusion method, among its other advantages, promotes the use of skills in academic and out-of-school settings and uses transfer as just another stage of the instruction method. This is a possible explanation of the fact that its effects persisted 1 year after concluding the intervention because, if the individuals trained in thinking skills were not using after completing the intervention, the effects would have disappeared sooner. The results of this investigation exceed those obtained by Tomic et al. (1993), who measured the permanence of the improvements achieved only four months after concluding the intervention.

General thinking skills have always been thought to facilitate comprehension and evaluation of syllabus content. This study provides support for this statement, because it was observed that the continued and varied practice of each thinking
skill led to the improvement of the students’ global performance (Perkins & Salomon, 1989). Therefore, teachers and students appraised both the IM and the IEP positively, although in the latter, transfer to the students’ academic requirements was not significantly attained.

Although the infusion method seems to be more effective than IEP with regard to the variables contemplated in this study, it is, however, difficult reach definite conclusions about which intervention is more appropriate because some differences are observed in the method when comparing some of their characteristics. For example, the nine instruments of the IEP were practiced for 120 h, and more than 600 h were dedicated to learning the contents and practicing the skills for the infusion method; with regard to training: the investigators who taught IEP had already received 70 h of training in the program, and the teachers who worked with the infusion method received 55 h of training and 24 h of tutoring; the investigators who taught IEP had had approximately 10 years experience with it, and teachers who taught the infusion method had had about 2 years experience; the teachers of the IEP group and their students considered the program to be interesting but far removed from the real learning process; the teachers and students of the infusion method considered it very useful because it integrated cognitive skills and syllabus content. Moreover, after observing how their students worked during two academic courses, the investigators concluded that, in comparison to the IEP group, the students who followed the infusion method engaged more in the learning tasks and displayed their competence in solving problems and producing ideas sooner. And these impressions of the investigators were somehow confirmed by the statistical results.

On the basis of the two interventions presented, we could recommend some activities for research and education. Regarding research, it would be appropriate to conduct a longitudinal study covering all the stages of the educational system, applying the infusion method. We agree with Howe (1997) when he says that it is reasonable to assume that intervention periods expected to produce significant improvements should last at least as long as the amount of time needed to gain sufficient experience in field, such as music and sports. With such longitudinal investigations, the most useful skills for each educational stage could be determined and it could be ascertained whether some cognitive processes are more sensitive to change than others. Researchers could also evaluate the quality of the teaching methods employed, and lastly, re-evaluate the reliability and internal consistency of the infusion method.

Concerning education, if thinking skills are so necessary to achieve certain educational goals, we propose to gradually incorporate teaching them into the educational system so that thinking skills would become the core of the academic curriculum. The conjoint and intentional teaching of thinking skills and syllabus contents should be fully implemented in the educational system because this would promote cognitive re-organization, the disposition to reflect, the awareness of cognitive aspects, and the persistence of such dispositions.

The educators were also very present in the investigators’ minds. For this study, we wanted to prepare them carefully to work with the infusion method. Without their collaboration, it would have been impossible to achieve the efficacy that was, in fact, attained. The new didactics they employed are valued by Lohman (1992), who states that a type of education that places emphasis on facts produces a type of student who is different from the student produced by an education that places emphasis on thinking processes. The latter type of education prepares students for real life by teaching them to transfer what they learn to real-life situations, either personal or professional.

Lastly, we would like to comment on some limitations of this study. First, the three studies were carried out with entire classes in which assignment of students and teachers was not completely random. Second, as has occurred with other interventions similar to this one, it could be that both teachers and students were especially interested in the infusion method and the IEP. If this is totally or partially responsible for the greater gains in the experimental groups, then we accept it with pleasure.

To end, one could say that: (a) the construct of thinking is very hard to understand unless its theoretical contents are experienced in real-life situations, mainly in educational settings, despite the difficulties to interpret it; (b) in some sense, people who study thinking should be practical investigators, and (c) probably, in this work, as in many others, the variables of thinking and self-regulation shared some variance so that they interacted positively in many tasks (Veenman, Elshout, & Meijer, 1997).

### Appendix A. Appendix A Guideline of activities to carry out in each stage and didactic unit

<table>
<thead>
<tr>
<th>Stages</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Organize the information about the topic</td>
<td>Relate to prior knowledge and personal experiences. Specify the terminology known about the topic to be studied. Seek relevant information about the content. Establish comparisons among this information. Formulate questions about the content.</td>
</tr>
<tr>
<td>(2) Define the goals to be achieved</td>
<td>Describe what should be learned. Specify the goal of the thinking skill and of the contents. Consider the importance of the didactic unit from a personal viewpoint. Select the appropriate strategy to learn. Specify the evaluation criterion that will be used at the end of the unit.</td>
</tr>
</tbody>
</table>
## Appendix A. (Continued)

<table>
<thead>
<tr>
<th>Stages</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3) Generate the largest possible number of ideas about the topic</td>
<td>Create many new ideas about the study content. Analyze the content from different points of view. Consult with experts on the topic. Make graphic, figurative, or numerical representations of the content. Foresee difficulties or problems with the content.</td>
</tr>
<tr>
<td>(4) Decide which is the best idea</td>
<td>Arrange the ideas discussed by their importance. Select the best. Examine the consequences of the decisions made. Plan the time intervals to be devoted to the work to be carried out.</td>
</tr>
<tr>
<td>(5) Verify the essential work of the unit</td>
<td>Make sure that the work is correct and the plan is being fulfilled. Make sure the assigned time intervals are met. Maintain interest during the entire process. Ask if one is committing errors. Observe progress in studying.</td>
</tr>
<tr>
<td>(6) Evaluate task performance</td>
<td>Appraise whether the goals of the skill and the contents were achieved. Detect whether errors were committed. Ask if one could improve in future activities. Evaluate personal participation in the group task.</td>
</tr>
<tr>
<td>(7) Communicate to classmates what was learned</td>
<td>Present the individual work to the class group. Justify one’s own ideas in front of the classmates. Contrast one’s individual work with that of other groups. Compare works with the criteria formulated at the beginning of the unit.</td>
</tr>
<tr>
<td>(8) Learning from experience</td>
<td>Summarize personally what was learned. Compare what is known at the end of the unit with initial knowledge. Transfer what was learned to other situations. Identify the thinking skills that were practiced during the didactic unit.</td>
</tr>
</tbody>
</table>

## References


