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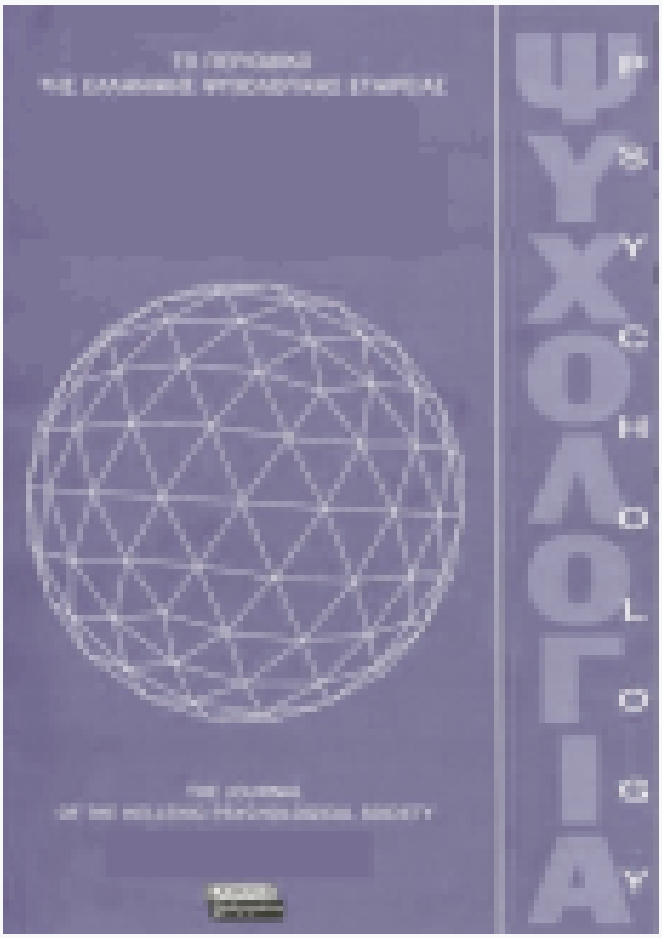

Teaching thinking skills: The challenge of learning to teach

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Teaching thinking skills: The challenge of learning to teach

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ABSTRACT Two approaches to teaching thinking skills have been described in the literature: an infusion and a direct approach. An infusion approach centers on the development of these skills and strategies within the classroom embedded within the standard academic content matter; a direct approach, on the other hand, fosters the development of these skills in students independent of content matter. The advantages and pitfalls of each of the two approaches are analyzed pointing out that the most outstanding difference between them may be the trade-off between specific and general strategies and leading to the interest of their combination. The aim of this paper is to briefly present previous studies with both approaches and with their combination and then present some reflections arising from these experiences which may help future work along this line. Our results show that both approaches seem to be effective in teaching thinking skills and, in the conditions under which our study was carried out, their combination does not seem to lead to enhanced effects. Moreover, there are some specific effects and difficulties which arise along each of them as well as some unintended effects that have to be taken into account. The application and transfer of skills, necessary for effective learning, has to be made possible within the classroom context, where these skills can be applied within specific content matter. For this to be possible innovative teaching methods must be applied. The main difficulties found in both approaches lead to the conclusion that change must occur on a system-wide level and not concetrate on any of the parts involved in the process.

Key words: Study and learning strategies, teaching methods, thinking skills.

Introduction

As social demands ask for a more meaningful learning which can be applied and transferred to different contexts and can be continued throughout a person's lifespan, the educational community has sought for the best ways to achieve these goals. Two approaches to developing thinking skills and learning strategies have been described in the bibliography. On the one hand, an *infusion approach*, which centers on the development of these skills and strategies within the classroom embedded within the standard academic content matter (Resnick, 1987); on the other hand, a *direct approach*, centered on the development of these skills in students independent of content matter (Weinstein & Mayer, 1986). Elsewhere (Vizcarro & León, 1997), the advantages and pitfalls of each of the two approaches have been analyzed

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pointing out that the most outstanding difference between them may be the tradeoff between specific and general strategies.

The aim of this paper is to briefly present previous experiences with both approaches and their combination and then reflect on their results and on the practical issues related to the implementation of intervention work. This, we feel, may help further work along this line.

An infusion approach draws its strength from the development of strategies that fall on the specific pole of the continuum by utilizing teaching methods which are tailored to fit the needs of the individual and to build on his/her previous knowledge of a given content matter. The application of this methodology demands that teachers have not only a deep knowledge of the given content matter but also a thorough understanding of learning processes; both of these forms of knowledge will guide one's overall instructional design as well as those of specific activities and interventions. It also requires the use of flexible tools, such as dialogue, to carry out significant teaching activities, e.g., probing for existing knowledge or facing the student with conflicting evidence. The major difficulty within this approach probably lies in the weight of well established practices and the time, motivation and effort the teacher has available to overcome them and become proficient in these new, more demanding and challenging practices. In some educational systems, difficulty may arise between this style of teaching, which is very time consuming, and the freedom teachers have to depart from an overloaded curriculum. In fact, a decision has to be made to concentrate on the crucial parts of curricula since in depth work needs a considerable amount of time and it is not possible to work in this way on extensive programs such as the ones we usually encounter.

The rationale underlying a direct approach to learning strategies development, on the other hand, is to empower students in their learning through the development of very general and content-free strategies which they are expected to subsequently apply to any academic activity they have to undertake. As can be seen, the strength of this approach lies in the general nature of these strategies and the ability the student is expected to acquire to self-regulate the process of learning. The disadvantages, interestingly enough, stem from these same features: transfer of these general strategies to academic areas and contexts that widely differ from those in which they were learnt is problematic. In other words, the ability of the students to independently activate these strategies cannot be taken for granted.

Taking into account these considerations, we proposed that the two approaches are not contradictory, but complementary and can be used in combination in order to draw on the specific advantages of each of them. Following this reasoning, we carried out two studies to test this possibility. The first used a direct approach to train learning strategies in university students. The second tried to combine both approaches as we had previously suggested. The aim of both studies was to prepare students to be able to approach learning with the intent to learn, to build up meaningful relationships between previous knowledge and new information and between knowledge and everyday experience and, finally, to facilitate transfer of knowledge to new situations where it may be applied.

Previous experiences with both approaches

Work with students

Some time ago we reported a study with university students (Vizcarro, Bermejo, del Castillo, & Aragonés, 1996). The background of this study was the high rate of observed failure among these students and the well documented effort to train students to use more efficient studying and learning strategies (e.g., Baron & Sternberg, 1987; McKeachie, 1988; McKeachie, Pintrich, Lin, & Smith, 1986; Weinstein, 1978; Weinstein & Mayer, 1986, 1991; Weinstein & Underwood, 1985).

We started by giving the students a questionnaire which prompted them to assess

the methods they used while studying and learning. In this way, we hoped they would reflect on their own learning processes and this would help them to more wisely choose the learning strategies most appropriate for them personally.

The training program was designed to include the three types of knowledge involved in self-regulated learning as spelled out by Paris, Lipson, and Wixon (1983):

a. Declarative knowledge (of the different learning processes and strategies);

b. Procedural knowledge (being able to perform the strategies); and,

c. Conditional knowledge (knowing which strategy should be applied in a given situation to achieve a particular goal).

It should be noted that the content of this training program was viewed as a separate academic subject, which the students were free to choose and which included discussion and application of the material being learned. Moreover, the students were asked to choose a subject within their study area in which they would anchor the different activities carried out during the training. It was expected that this would facilitate the learner's ability to transfer these learning strategies to their specific academic content areas.

In order to keep the presentation of the training program consistent with the concept of active learning, the program provided a variety of activities: Before starting the presentation of any strategy we asked the students to make some observations in their daily life or while studying. Presentation of a strategy then started with in-class discussions on students' observations and feelings towards the relevance and effect of the various learning strategies to be learned. Additionally, classroom time regularly included explanation, practice, feedback and discussion of the relevance of learning strategies as they applied to the specific tasks and contents students were taking. Out-of-class tutors were available to provide support on an individual basis in an attempt to enhance transfer to natural contexts. We worked with groups of students as homogeneous as possible as regards the subject-matter they were taking.

Table 1
Content of the student training program

1. Support strategies
    a. Self-control
        i. environmental working conditions
        ii. time planning
        iii. preparation of learning material
        iv. physical conditions
    b. Motivation
    c. Anxiety control
    d. Cooperative learning
2. Cooperative strategies
    a. A cognitive model of learning
        i. attention and schemas
        ii. memory
    b. Text and language comprehension
    c. Spatial strategies
    d. Written composition
    e. Problem solving
    f. Metacognition

The topics of the training program appear in Table 1 and they were offered as separate optional modules that students could take partly or as a whole. The total duration of the program was approximately 50 hours.

In this study experimental and control group scores were measured on the Learning Strategy Questionnaire (IDEA) (Vizcarro et al., 1996). An ANOVA was performed on these data with one between-subjects factor (experimental, control groups) and one within-subjects factor (pre, post conditions) to measure change. Results indicated that the intervention had a significant positive effect on the experimental group while the control group showed no significant change between their pre- and posttest scores. Students who took the course also showed higher academic grades after the intervention and the evaluation of the program indicated high acceptance on the part of the students. Apart from the results derived from the statistical analyses, students showed a deep interest in the topics that were being dealt with throughout the course. In addition to this, after the end of the course, they enthusiastically and spontaneously reported that the activities had been very useful to them in order to cope with the tasks they had to perform in their regular classes.

Work with teachers and students

After this successful experience we attempted to expand the application of this method to secondary school students while at the same time trying to get an indication of the relative gains associated with the infusion and direct approaches and a combination of the two as we had previously suggested. With this idea in mind, we carried out a study whose main goal was to estimate the effect of each of these approaches.

This research took place in different phases organized throughout the 1995-96 academic year. The experimental sample comprised six secondary school teachers, who taught Mathematics, Biology and Philosophy at three public schools in Madrid, and their students. Three other teachers from the same schools and in the same subject-matter areas also participated with their students forming the groups of the direct approach and the control group. There was no further contact with the teachers and their students in the control group except only at the times of pre- and post-assessment; the participants in the direct approach group followed a similar procedure to that described in the previous section. The total sample comprised 315 students, who were distributed into groups according to the following intervention conditions:

a. Direct approach to learning strategies (DALS)

b. Work with teachers (WT)

c. A combination of the two preceding conditions (DALS + WT)

d. A control group without any intervention.

The procedure used in the DALS condition was similar to the one described in the previous section. For the WT condition, it was necessary to design a procedure to guide our work with teachers; the aim was that they infuse in their classrooms "learning to think" activities. This work focused on two main components: teaching activities and assessment methods. Assessment was given special attention considering its role in defining learning criteria (Frederiksen, 1994; Resnick & Resnick, 1990). The topics covered in our work with teachers included those described in Table 2. The two first authors acted as trainers with this group of teachers.

The procedure was as follows. As a first step, teachers filled out a self-observation form containing a variety of topics regarding conceptions of learning and teaching practices which were explored and discussed with them later on. On the one hand, we discussed how they understood learning, which learning activities of the learner they believed to make learning possible, how could teachers help learning to occur, what were the difficulties their students found in their classrooms, how could they be assured that learning had taken place. On the other hand, teachers described their own

Table 2
Topics for working with teachers

1. What is learning?
    a. Types of learning
    b. Features of effective learning
        i. constructed
        ii. active
        iii. situated
        iv. social
        v. reflective
    c. Components of learning (Learner X Teacher X Content)
2. Description of learning strategies program for students
3. Principles of cognitive apprenticeship
    a. Identifying content:
        i. domain
        ii. heuristic strategies
        iii. control strategies
        iv. learning strategies
    b. Activities to enhance learning
        i. modeling
        ii. coaching
        iii. scaffolding
        iv. articulation
        v. reflection
        vi. exploration
        vii. cooperative learning
    c. Sequence:
        i. increasing complexity
        ii. increasing diversity
    d. Complementarity of teaching, learning, and assessment
4. Teaching and learning through projects
5. Alternative methods of assessment

teaching practice: how they tried to motivate their students, to help them understand, to apply and transfer newly acquired knowledge and, finally, the methods they used to assess their students.

In this way, and mainly starting from the difficulties they experienced in their classrooms, teachers were involved in a series of discussions in which their own conceptions of learning, teaching, and assessment were looked at, reflected upon, and the implications of stated beliefs discussed. Then alternative views and methods were introduced and supported with a selection of readings. As was expected, teachers' conceptions of learning leaned heavily on the side of traditional approaches, where the teacher is considered the transmitter of knowledge and the student is seen more or less as a sponge ready to absorb whatever the teacher pours into him/her. Our goal was to analyze the difficulties the teachers reported from this perspective, then try to help them see the added benefits of constructivist approaches to learning. These benefits rely on the idea that a learner comes to any learning experience with a firm knowledge

base that will influence the way in which s/he learns, interprets, and experiences new material. We also tried to provide evidence that learning should be interactive and based on meaningful, authentic situations in which the learner is expected to use critical-thinking skills to solve real-life (or close to real-life) problems (Bednar, Cunningham, Duffy, & Perry, 1992; Duffy & Cunningham, 1996). Within this approach the teacher is seen as a facilitator of the learning experience, a person who provides experiences and uses dialogue to stimulate and direct reflection (Vizcarro & León, 1997).

These approaches, however, do not necessarily translate into practical in- and out-of-class activities. Teachers need to transfer these reflections to specific activities to be used within their content area. Therefore, after the discussions took place, teachers were asked to develop a small project within their subject-area and apply the new concepts and approaches. The project included selecting specific content and setting goals and work methods to be used as well as selecting (or creating) materials and assessment procedures. Teachers working in the same or similar content areas were able to work collaboratively on some of these aspects.

We analyzed the results of this work taking into account, on the one hand, changes in teachers' practice and, on the other, the impact these changes had on students. Our first step in the analysis of the results was to try to contrast our hypothesis that work with teachers would have an impact on their teaching practice; that is, did they resort to teaching methods that could be considered more in line with constructivist, learning-by-doing approaches and approaches that take into account student learning processes or not? However, this contrast could not be investigated through independent classroom observations, although they had been planned, since teachers did not feel comfortable with having observers in their classrooms. Nevertheless, they were willing to answer again at the end of the year the same self-observation form about their teaching ´conceptions and practice they had filled out at the beginning of the year. Independent of the measurement bias (or reactivity) this method most certainly introduces, it is worthwhile noting that analyzing their teaching styles in order to respond to this form provided the teachers with an important opportunity to reflect on their views on teaching and learning and gave the recent changes in these views a chance to crystallize. Actually, and we shall come again to this point later on, this opportunity for reflection was seen as a turning point by all the participants in the study, teachers and trainers alike.

Additionally, several procedures were prepared in order to analyze the effect of the various conditions (DALS, WT, and DALS + WT) on students' learning strategies. The complete assessment scheme included:

Text (specific). Two texts were prepared by the teachers related to their own subject area. Appendix B shows one of the texts dealing with trigonometry. The main purpose of this measurement was to have an estimation of the specific effects of the conditions on a specific domain. Two texts of similar level of difficulty were prepared, since the use of the same text for the pre- and post-assessment could have biased the results through familiarity of the material. The text was then given to the students, who were asked to read it in the way they would usually study in order to prepare for questions they would answer afterwards. As can be seen in Appendix B, the questions asked covered a wide range of knowledge acquisition through text reading: facts and concepts described in the text as well as inferences and analogies and application of knowledge to solve new problems similar to the ones described in the text. The questions were as follows:

a. ***Give the text a title.*** The intent of this task was to capture the students' accuracy in understanding the superstructural information of the text.

b. ***Write a summary.*** This item was meant to test the conception of the macrostructure, or main ideas of the text, as well as the microstructure, or secondary information contained in the text.

c. ***Multiple-choice questions.*** Through a series of multiple-choice questions we tried to measure mainly factual information in the text.

d. ***Essay writing.*** Through some essay questions we tried to assess transfer to new situations, search for causes and/or consequences, and ability to generate analogies.

Text (general). Two texts of general nature, not directly related to any of the content areas imparted by the teachers who participated in the study, were also prepared. The main purpose of this measure was to have a direct comparison of the effects of the various interventions since it was intended for all the participants to answer. The texts used dealt with transportation of petroleum and sea pollution and the effects of paper use on environmental pollution.

Other measures of learning strategies use were also taken which will not be reported here. Unfortunately, the complexity of the design created major difficulties, and measures of the general text could not be collected from a sufficient number of students under the various conditions. This made the relevant comparisons difficult.

There was, nevertheless, a sufficient number of measures for the specific text (N=217) distributed throughout the four groups. Their size ranged from N=24 to N=106 students. The dependent measure was an overall measure encompassing all the previously mentioned items of the speficic text comprehension task. A simplified version of these results is shown in Figure 1. A repeated measures ANOVA was performed with one between-subjects factor with the following levels: DALS, WT, DALS+WT and Control groups and one within-subjects factor (pre and post conditions). This analysis and later comparisons showed, as can be seen in this figure, that all three interventions produced significant gains on this measure as compared to the control group; however, none of the interventions could be said to have attained better results than the others. Actually, the three

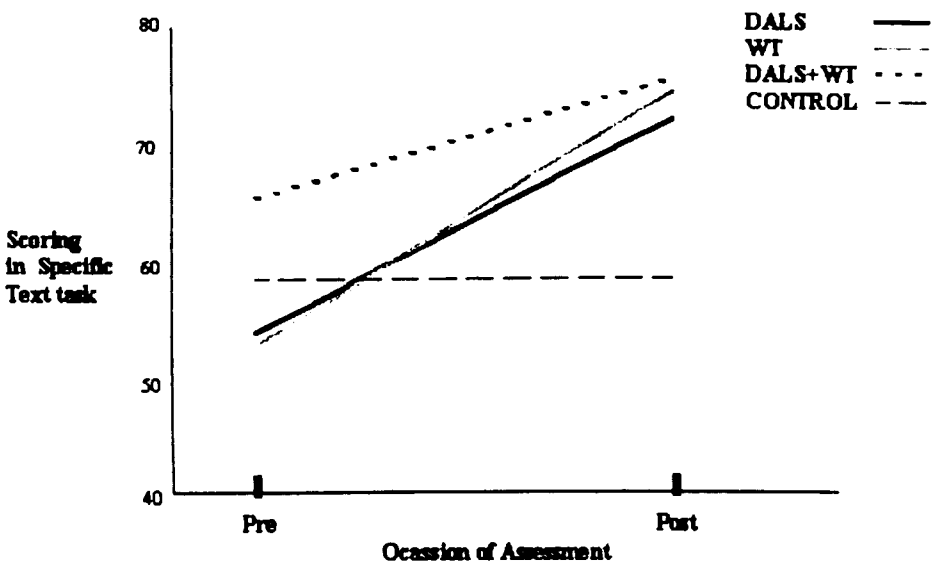

Figure 1
Representation of the means of the variable "Specific Texts" for each group before and after the intervention.

of them seemed to have reached a similar point which may represent a ceiling for these groups of students.

Thus this study seems to show that both conditions (work with students and teachers) produced a significant gain over the control group. However, taking into account the conditions under which our study was carried out, neither of them could be considered superior to the other and their combination did not lead to enhanced effects. These results should be considered modest, taking into account the applied setting under which this study was performed. Yet, some interesting observations were made during the development of these studies which may be of interest for subsequent work. These will be addressed in the next section.

Some reflections on previous work

We shall reflect on these observations in the following section considering, firstly, the direct work with students and, secondly, with teachers. Most or even all of these observations may seem quite self-evident; however, we feel that discussing them may help make future efforts along this line easier or, at least, more focused on crucial issues.

Work with students. Notwithstanding the previous successful experiences with university students, it soon became evident that work with secondary school students had its own peculiarities:

1. In the first place, the material that had been prepared for university students did not seem as interesting to secondary students as it had proved for their older counterparts. This was so apparent that the format of the course had to be modified, changing it to the carrying out of a project in which the topics included in the course were dealt with. Editing a newspaper was a project they found interesting and also included most of the topics in the learning strategies course.

2. In our previous experiencé with university students, tutors of the learning strategies course were doctoral students in Education working within a research project. Thus the training of these tutors was much easier and their work with students may be considered as taking place under tightly controlled conditions. In this new setting, however, interested professionals from the orientation departments of the schools acted as tutors. They had a background in Psychology and a more applied profile, compared to tutors in our previous study. Their training proved considerably more difficult and took more time and effort, and, in subsequent comments along our work with them, we had reasons to doubt they had grasped the main goals of the learning strategies course. In fact, this work very much resembled that which we carried out with teachers participating in the study. Thus, and even if the material for the course was highly structured, it was obvious that extensive work was needed to train tutors who were not familiar with the material. This obviously casts doubts on the feasibility of training tutors on a broader base, thus setting the same practical limitations on this kind of work as with training teachers.

3. The activity on learning strategies with students was not part of the overall school plan; this means that it often clashed with other school activities such as a "cultural week" or a "snow week." This resulted in the activities having to either compete for time, and importance, with the previously scheduled school activities or be postponed. In some of the schools, difficulties were even occasionally encountered in finding a place to carry out the activity. As a result, the program took longer to develop than was foreseen and often lacked continuity. Not infrequently, this lent a feeling of oddness to the project. This did not happen, however, in one of the schools where it could be fit into a prescheduled time. This finding brings to the fore the need for this kind of activities to be invested with a significant role within the whole system lest their meaning is diminished.

4. It was also observed that these students who were in classrooms where the learning strategies that were taught were not required (or were even downplayed by the teacher)

understandably had more difficulties adhering to the course and, of course, did not apply the strategies they had learnt. Again, this points to the need for these programs to be a meaningful part of the whole system and enjoy the appreciation of all the participants so that they can play a significant role in the teaching and learning process.

5. As anyone working with teachers knows well, teachers working from a traditional approach often complain that the outcome of the teaching and learning process is not as good as it would be desired because students do not behave as expected (e.g., do not pay enough attention, do not understand well when they read, are not motivated, do not transfer acquired knowledge to new situations, etc.). In other words, they do not learn as they should because they lack learning strategies. In so doing, the part played by the teacher, and the role of the teaching tasks and materials tends to be ignored. It was felt that having someone from outside the class working with students on these topics could stimulate teachers even more to focus on their students to explain undesired results. Thus, training students to use learning strategies in separate programs may have the unexpected result of reinforcing this traditional attribution of teachers, thereby making teacher-led innovation more difficult.

As discussed above, these difficulties did not impede positive effects for those students who followed the course to its end. However, for this kind of activity to be successful, the difficulties just discussed must be foreseen and adequately dealt with from the beginning.

Work with teachers. Two sets of difficulties were encountered in our work with teachers, those directly related to our work with them, on the one hand, and those having to do with general conditions of teaching and learning in secondary schools on the other.

1. Although the participating teachers were all "interested" in change, many of them were clearly quite resistant to actually making the change. This reflects the idea that change of this sort occurs over time as teachers grapple with their own conceptions and procedures of learning, with new conceptions and procedures, and their attempt to make sense of it all. In addition, they are usually unsure as to how fellow teachers, parents, students, and administrators will react to the new conceptions and procedures, whether discipline in the classroom will suffer, and whether they will be able to teach to their students the knowledge and skills that are expected of them. It seems clear that change must occur on a system-wide level and not only fall to teachers. Otherwise the effort is so huge and the outcome fraught with so many contingencies they might feel it is wiser to leave things unchanged.

2. It was evident from the beginning that trying to change teaching practice is hard work which takes place during an extended period of time for all the participants involved. Even teachers literate in current teaching and learning theories require a significant conceptual change which is not easy and is reached through a long, effortful process. Actually, in our view, a critique can be addressed to school reform, at least in this country, in that, paradoxically, it has approached teacher education in an indirect, expositive way. This can be seen as paradoxical since this is exactly the very type of practice which it tries to overcome, thus giving an obvious double message to teachers. On the contrary, if this change in conceptual understanding of teaching and learning is to take place, we believe it has to be approached by providing a meaningful learning experience and plenty of opportunities for discussion to teachers, parallel to how it is supposed to happen for students. It is through a long process of reaching new understandings, putting them into practice, and reflecting on the outcomes of their efforts that help teachers significantly change their views on the process of teaching and learning and their ensuing practice. In other words, it should be a "learning through experiencing and doing" process.

3. This long process of work and change further requires close attention and follow up of teachers' efforts, providing the amount of

support they will surely need to advance in their own way on an individual basis. In our view, this challenges the value of activities arranged for the professional development of teachers which are extremely limited in time. On the contrary, a period of follow up where they try to apply their evolving views seems of fundamental importance if change is to occur.

In this line, group work with teachers is also considered crucial for its cognitive effects, as well as for the motivational and emotional support it provides. We worked with a mixed group of teachers who taught in different subject areas. Initially, it was thought this would make for richer discussions. However, we realized that the differences between the various subject areas were too great to allow teachers to learn from discussions that often seemed to some of them to become unfocused and caused them to drop out of the discussion. In order to make discussions more engaging and fruitful, it might be advisable to work with teachers who share common subject-matter demands.

4. The observation that teachers seemed to profit very much from experiences where a concrete tool (this term is used here in a broad, Vygotskyan perspective) was proposed was very interesting. We have discussed above how filling out a form on their teaching conceptions and practice seemed to be of much value to them. It certainly helped them to reflect on their practice with some specific questions in mind. An analysis of the task proposed in Appendix B through the framework offered by Collins, Brown and Newman (1989) also seemed to stimulate them to produce further activities trying to cover the whole spectrum of skills embodied within their discipline.

5. Other difficulties arose from more general conditions of teaching and learning in secondary schools. One that stood out in particular had to do with the amount of curricula teachers were expected to cover through the academic year. Helping them reach a compromise whereby they could work more in-depth with topics they considered nuclear, or especially difficult to grasp by their students, yet, at the same time, impart more conventional lessons in other topics was not without its difficulties. Even if, in principle, they had room for freedom to make these kinds of decisions, they were especially resistant to the possibility that their students would pass on to the next level having missed a substantial part of the topics they were supposed to cover. Again, this takes us back to the need for change to be approached in a more systemic way and to consider the severe restrictions of individual decisions to innovate when taken within a school context which may not understand, let alone value them. However, it is hoped that further experience with new methodologies and observation of their outcomes may help them make these decisions easier and even act to activate change within their context.

6. Another serious limitation had to do with the difficulties of finding the right time to meet with the group of teachers, given the tight time schedule they usually had to endure. A possibility (that we are currently trying to apply in a different context) is to have at least part of these exchanges electronically, not excluding but limiting the time allotted for face to face meetings. This may make it easier to keep in contact on a continuous basis, an element which is felt to be of crucial importance for the effective functioning of the group since it helps to keep and strengthen the personal relationship which is also considered fundamental for the cohesiveness of the group and the emotional support it may thus give to participating teachers.

Conclusions

Thus in the conditions under which our study was carried out, an infusion and a direct approach to train efficient learning strategies seemed to have very similar outcomes and, contrary to our expectations, their combination did not seem to attain enhanced effects. However, it seems clear from these experiences that, apart from the approaches per se, many other factors need to be taken into account in

order to ensure the best possible outcome. Outstanding among these is the place these innovations play within the system represented by the school.

It seems clear, from the experiences discussed above, that long and hard work is to be expected by professionals wishing to work from any of the two approaches discussed above. A great deal of effort is needed on the part of all participants, especially teachers. A fair amount of motivation needs to be at work from the start and then be fedback by positive effects following the innovation which are well valued by the context in which it takes place. Of course, this brings the whole issue to the context within which the experience is to be developed or, in other words, to the whole system where it takes place. And by "system" we mean the overall educational system as well as the particular school where this kind of work is undertaken.

Teacher or tutor trainers also need to be motivated for sustained work adapted to the needs of the participating teachers and of the particular school. On the other hand, both approaches need to be embedded in a context where innovations are valued and supported, not interfered with. If this is not so, the effort described above will need to be even greater and the motivation may eventually die out.

Partly in connection with this last point, the more effective way to work, in our view, is in groups since this helps create a more adequate climate within the institution. On the other hand, the emotional support provided by the group should also be considered. Along this line, attention should be given to the characteristics and dynamics of the group we are working with. Electronic means to maintain a good level of communication and facilitate follow-up can be of help. In this way, time schedules need not be such a serious problem as they usually are. Face to face contacts and meetings should not be eliminated, since they serve the purpose of giving cohesiveness to the group and enhance personal support to the individuals. However, their frequency can be diminished, decreased, while still keeping their role of sustaining social and personal support.

To summarize, the difficulties faced by both a direct and an infusion approach share many similarities. These have to do with the vicissitudes of change, on the one hand, and with the necessary application and transfer of the skills learnt on the other. Both of them are, through various paths, intimately related to the context in which these efforts are taking place. It is obvious that this work becomes much easier when it is coherent with goals valued by the system where it is embedded and, on the contrary, is made difficult when they are isolated efforts. Application and transfer of higher order cognitive skills also require a context in which they make sense. An appropriate context will lessen the effort needed for change, even call for change and make application easier or even necessary.

This statement may seem very obvious and it takes us back to how this favorable context is established. Although the answer to this question can be quite complex, it might be recognized that individual change, however stressful, may be one of the main routes. While this happens, however, being cognizant of the difficulties and limitations one faces may at least guard from frustration.

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Appendix A

The purpose of this activity is to have students use trigonomic principles to measure the height of objects which cannot be directly measured (see below Route used for the activity). With this end, students have to make a rudimentary theodolite to measure the relevant angle. Illustration 1 shows an example of a measurement of this type. The activity was done in groups with all students being responsible for measuring the height of the chosen building. In this way, students had to compare their measurements and confirm that the results were all the similar. If not, they had to come to a group decision as to how the correct measurement should be determined and apply that decision. They were expected to work collaboratively as a group and use self-correction techniques and critical thinking skills in order to determine whether or not the obtained results were plausible. When the activity was completed, they were given a self-evaluation form in which they were required to express what they felt they had learned by doing the activity.

Theodolite

A theodolite is an instrument used in topography to measure horizontal and vertical angles with great precision. The students made their own theodolite using a solid base, a level,

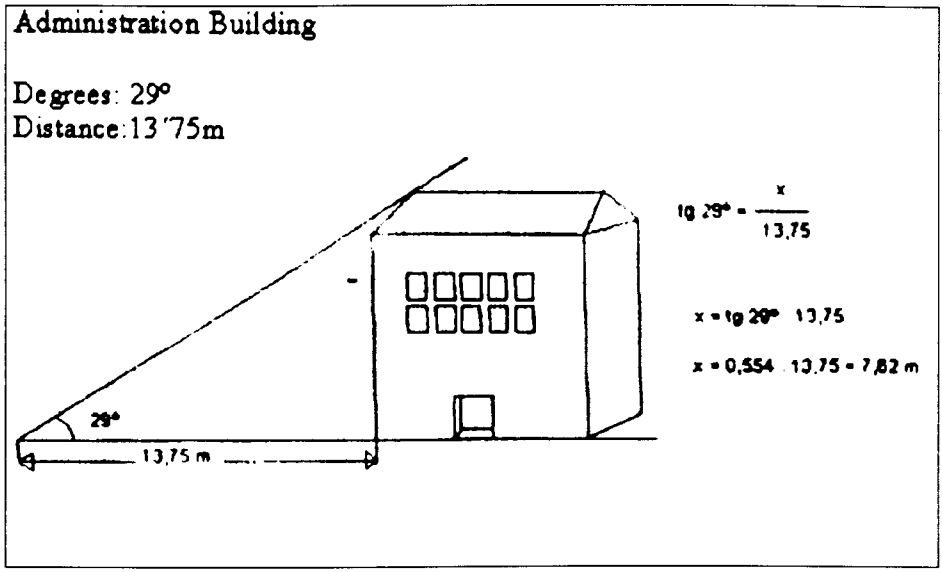

Illustration 1:
Example Measurement

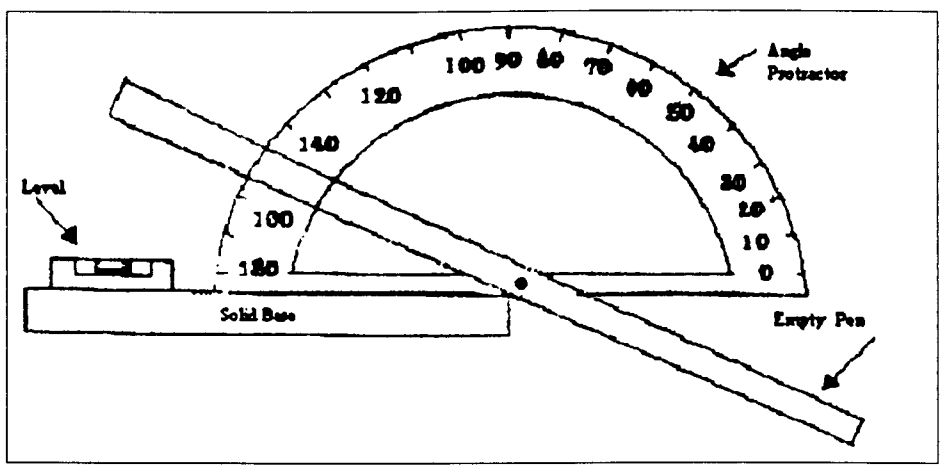

Illustration 2:
Students' theodolite