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The Impact of Cognitive Education Training on Teachers' Cognitive Performance

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Cognitive education is usually considered in terms of its impact on students' problem-solving skills and their acquisition of disciplinary knowledge. Little is known about the impact of cognitive training on the cognitive skills of teachers themselves. In this pilot study, 80 South African high school teachers participated in the cognitive education (Instrumental Enrichment) course and then implemented the principles of cognitive teaching/learning in their classroom instruction. Teachers' problem-solving skills were evaluated before the start and after 9 months of training and implementation. Significant changes were observed in teachers' problem-solving performance. Teachers with better mastery of cognitive education program also demonstrated better cognitive task performance on the posttest. Teachers with weaker pretraining cognitive performance made greater relative gains than teachers with stronger initial performance. Recommendations are made regarding the use of Instrumental Enrichment as a tool of cognitive enhancement for teachers.

Keywords: cognitive education; teachers; Instrumental Enrichment; problem solving; South Africa

Since the 1980s, cognitive education in its different forms has become a more or less permanent feature of educational systems (Harpaz, 2007; McGuinness, 2005). The effect of cognitive teaching relative to other forms of educational interventions is still vehemently debated (see Hattie, 2009 for meta-analysis). The focus of the debate, however, is almost exclusively on the contribution of cognitive programs to students' thinking skills and curricular performance. There is a limited amount of research done on the possible impact of cognitive training on teachers' own cognition (Day, Colderhead, & Denicolo, 2012; Zohar & Barzilai, 2013). When such a research is conducted, it focuses predominantly on changes in teachers' instructional style or attitudes toward less successful students (see Baumfeld, 2006). For example, in several studies reviewed by Baumfeld (2006), the focus of research was on changes in teachers' questioning behavior. By using higher order questions in their practice,

teachers create a framework for a dialogue in which students are encouraged to probe into the underlying reasons behind the answer to make judgments and justify their conclusions. Asking more open-ended questions was also linked to allowing more time for students to think before answering and encouraging them to extend and develop responses. Another popular topic of research is the change in teachers' attitude toward less successful students and the creation of a more inclusive atmosphere in the heterogeneous classroom (Ferretti, MacArthur, & Okolo, 2001).

At the same time, it was observed that teachers' own metacognitive skills are often imperfect, and their understanding of higher order thinking is imprecise (Zohar, 2004, 2006). One of the factors that apparently impacts on the teachers' attitude toward and understanding of thinking skills is their more general pedagogical views. In her study of science teachers who participated in the Thinking in Science Classroom professional development seminar, Zohar (2004) demonstrated that those teachers who displayed a more "constructivist" pedagogical outlook were also more process-oriented in their understanding of thinking skills. At the same time, those teachers whose pedagogy was based on a teacher-to-student transmission model perceived teaching thinking as a transmission of specific problem-solving rules and algorithms in a ready form from teacher to students. The latter group of teachers systematically lowered the cognitive demands of the thinking task because they provided students with a ready solution algorithm.

The aforementioned studies were almost without exception of an "infusion" type, with cognitive skills infused into specific curricular material. The infusion approach preserves teachers' privileged position because their knowledge of curricular material is better than that of their students. Even when teachers use an inefficient thinking strategy, they most probably come to a correct result because they already know all the correct answers. In terms of analysis, it is also not easy to separate thinking skills as such and thinking skills in their content-embedded form. In other words, even in the research dedicated to changes that occur in teachers who participate in cognitive programs, it is not easy to identify what happens with teachers' own "pure" rather than "infused" cognitive skills and problem-solving strategies. On the other hand, it seems important to clarify this point because modeling is considered as one of the main methods of instruction. When teachers are hesitant in their own cognitive problem solving, this may affect their ability to model cognitive strategies to their students. An important difference between cognitive and curricular performance is that in curricular areas, teachers are almost by definition ahead of their students because the amount of their disciplinary knowledge is greater, whereas in the cognitive area, teachers and students are often "on equal footing" because cognitive tasks do not require any domain-specific knowledge.

One of the reasons for the paucity of research on teachers' cognitive skills might be related to the belief that cognitive change, if at all possible, is restricted to childhood and adolescence and that adults have already reached their cognitive ceiling (Kaufman & Lichtenberg, 2006). Another possible reason is the reluctance of teachers to become a target of any kind of evaluation that might expose their cognitive problems and in this way undermine their educational authority.

In this respect, Instrumental Enrichment (IE; Feuerstein, Rand, Hoffman, & Miller, 1980) seems to be in a somewhat better position than other cognitive programs. The value of this program for the development of cognitive skills of preservice teachers was elaborated by Martin (1984). The IE program consists of a series of paper-and-pencil tasks in such areas as analytic

perception, comparison, classification, orientation in space and time, syllogistic reasoning, and so on. The IE tasks are deliberately designed as content-neutral and do not require any particular disciplinary knowledge. There are no “answer sheets” with correct answers, so in the course of training, teachers are expected to find the optimal solution strategies. Although some of the tasks are rather simple, some are complex enough to be challenging not only to students but also to teachers.

Both the teacher training process and the classroom application are highly interactive. During the teacher training, the participating teachers are engaged in active dialogue with IE mentors advancing, testing, and justifying their problem-solving strategies. In this way, teachers become more aware of the cognitive aspects of any problem-solving situation and gain insight into the cognitive difficulties experienced by both themselves and their students. The application of IE in the classroom is also interactive with teachers acting as mediators to their students rather than being providers of “correct answers.”

Martin (1984) demonstrated that preservice teachers who received an IE training course developed more advanced cognitive skills related to precision in written description and explanation of pictorial information. They were also better in identifying similarities and differences, and their learning style was more reflective than that of comparison students who studied no IE. Silverman and Waxman (1988) reported that in-service teachers who received IE training started posing more conceptual questions and, in this way, engaged their students in higher level dialogue. The same study also demonstrated an advantage of IE teachers versus non-IE comparisons in deploying decision-making strategies. Kozulin (2005) explored the impact of IE training on problem-solving and metacognitive skills of in-service Israeli teachers. Teachers were asked to solve some of the IE tasks and describe their solution strategies before the start and then again after 90 hr of IE training course. The study confirmed that some of the IE tasks were quite challenging to the future IE teachers and that the teachers' ability to reflect on their problem-solving strategies improved significantly after IE training.

The first attempt to explore the impact of IE training on cognitive performance of preservice teachers in South Africa was undertaken by Skuy, Lomofsky, Fridjohn, and Green (1993). The study was conducted under conditions of still segregated teacher training education where White, Black, and Colored¹ teachers were trained in separate colleges. Ninety-two Colored preservice teachers received IE training for 31 hr, whereas the other group ($N = 31$) served as a “control,” receiving just a typical teacher training curriculum. The teachers were tested before the start and after the end of training using a battery of cognitive tests including the Similarities subscale of the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981), verbal combinatorial thinking test (Organizer; Feuerstein, Rand, & Hoffman, 1979), Raven Standard Progressive Matrices (Raven, 1958), and reading comprehension test (Bormuth, 1968). There was no significant difference between the groups in the pretest in either one of the measures. The analysis of the pretest to posttest changes revealed significant although modest advantage for the IE group. For the future discussion of our own results, the results of Skuy et al. on the verbal combinatorial thinking test (Organizer) are particularly important. The effect size of IE training for this test in the Skuy et al. study was 0.4 *SD*. It should be taken into account that the number of IE training hours in the Skuy et al. study was much smaller than recommended by Feuerstein et al. (1980) who suggested at least 80 hr of training for teachers applying the program in primary schools and up to 160 hr for those who plan application in high school. There are several conclusions to be drawn from the Skuy et al. study. First, it became clear that preservice teachers were far from reaching the ceiling in their

cognitive performance. In other words, participation in IE training enhanced their verbal cognitive and reading comprehension functions. Second, the participants themselves became aware of their cognitive needs, and 95% of them acknowledged that IE training helped them to improve their hypothetical reasoning, control of impulsivity, and planning behavior. Third, 97% stated that IE training had an impact on the way they teach in the classroom.

The conclusion from the aforementioned short review is that only a rather limited amount of research is available on the impact of cognitive training on cognitive performance of pre- and in-service teachers. At the same time, the need for such research may become critical in the context of the current trend for considering the development of thinking skills as one of the important objectives of any educational system. The following study was aimed at providing some insight into the cognitive change that took place in in-service high school teachers in South Africa who received extensive training in IE.

THE SOUTH AFRICAN TEACHER TRAINING PROJECT

This study was conducted in a realistic context of a teacher training project in South Africa. For this reason, it was impossible to have a comparison group—so all findings are tentative and should be further verified in further studies that include various comparison groups. The first objective of the project was to make public school teachers aware of the cognitive aspects of the teaching–learning process. The second objective was to transform them from mere providers of curricular information into mediators of learning strategies to their students. Teachers invited to participate in the project taught Black and Colored students in schools located primarily in economically depressed areas. The ultimate goal of the teacher training project was to improve the level of instruction and eventually bring more students to higher level school matriculation. These objectives were achieved through the following activities:

1. Preproject assessment. At the beginning of the project, teachers participated in dynamic assessment (DA) of their own problem solving. Usually, assessments, either static or dynamic, are conducted with students, and their results are used for the evaluation of the effectiveness of instruction. In our case, teachers were the subjects of assessment, and the assessment process was used as a tool for making them more aware of the cognitive aspects of problem solving and the modifiability of human intellectual processes. The teachers participated in the DA that included nonverbal matrix problems (Set Variations), number series tasks (Numerical Progressions), and verbal combinatorial reasoning tasks (Organizer; see Feuerstein, Feuerstein, Falik, & Rand, 2002). A distinctive feature of DA is the inclusion of the interactive learning phase into the assessment procedure (see Feuerstein et al., 1979). During the learning phase, the assessor cum mediator asked participants to look at the model problem, formulate the possible problem-solving strategy, and justify the selected response. Alternative strategies were further discussed, and possible reasons for selecting incorrect answers probed. After interactive work with model tasks, teachers were given similar but not identical tasks for independent problem solving. Based on the DA results, individual DA reports were written and presented to and discussed with the teachers. Teachers acknowledged that participation in the DA made them more aware of their own problem solving and at the same time helped them to understand difficulties experienced by their students and the ways these difficulties could be alleviated via mediated learning.

2. Cognitive training. Teachers were trained in the Feuerstein et al. (1980) IE program in four intensive week-long sessions for 160 hr. The training course included introduction to Feuerstein's theory of structural cognitive modifiability and mediated learning and hands-on experience with all 14 IE "instruments." The theoretical part of the course involved a study of cognitive functions and operations, criteria of mediated learning, goals and subgoals of the IE program, cognitive principles that can be derived from the work with IE tasks, and the technique of "bridging" these principles to various curricular areas. The instrumental part of training included hands-on work with IE tasks of various levels of complexity and preparation of lesson plans based on the cognitive principles of IE. The IE tasks focused on analytic perception, comparison, classification, orientation in space and time, understanding and creating instructions, syllogistic reasoning, and so on.
3. Implementation and coaching. Immediately after the end of the first training session, teachers were encouraged to start implementing the cognitive and meditational approach in their classroom teaching. Implementation of the cognitive principles continued throughout the school year. Specially trained IE coaches made four visits to the classrooms of each one of the teachers, observed their classroom performance, and provided them with constructive feedback. Lesson observation was structured by the use of the Cognitive Lesson Observation Scale that helped coaches to identify aspects of the teachers' performance such as the presence of the cognitive approach; didactic methods; quality of mediation; and efficiency in using time, equipment, and classroom environment.
4. Postprogram assessment and portfolio of implementation. At the end of the project, teachers took the tests parallel but not identical to those used at the start of the project. Unlike the pretests, there was no learning phase in the postprogram assessments. In addition, teachers were asked to solve four advanced tasks from the Instructions IE instrument. The assessment results were presented to the teachers so that they could compare their pre- and postprogram cognitive performance as well as their mastery of the IE instruments. Teachers also prepared the Feuerstein IE portfolio including program implementation information and lesson plans.

RESEARCH QUESTIONS

To what extent does participation in the cognitive training program improve the teacher's cognitive skills? This question is answered by comparing the pre- and postproject cognitive test results.

Is the improvement of cognitive skills correlated with the mastery of IE tasks? This question is answered by comparing the teachers' IE task and postproject cognitive test performance.

Is there a differential impact of training on teachers with initially different levels of cognitive performance? In other words, was the training program equally beneficial for all teachers, or only for those with initially stronger (or weaker) cognitive skills.

SUBJECTS AND PROCEDURES

This study is based on the assessment data of 80 teachers, 50 male and 30 female, who participated in all learning and assessments sessions. The age range was 23–61 years ($M = 42.18$, $SD = 7.8$). Based on the equity code, 5 teachers were identified as White, 14 as Colored, and

61 as Black. For the absolute majority (80%) of the teachers, one of the African languages was their mother tongue with English (the language of school instruction) being the second or third language.

The preprogram assessment included the following DA tests: Set Variations (matrix patterns), Numerical Progressions (series of numbers), and Organizer (verbal combinatorial tasks; Feuerstein et al., 2002). Each test included the learning phase and the test itself. Set Variations is based on the graphic matrix tasks similar to those of Series B, C, D, and E of the Raven Standard Progressive Matrices. Each series of Set Variations problems started with a model problem mediated to the learners by the assessor. Mediation included soliciting the learners' opinion about the nature of the problem, the best strategy for choosing the correct response item, as well as reasons why other responses items are incorrect. When necessary, the assessor corrected learners and suggested a more efficient problem-solving strategy. The assessor also generalized the discussed cognitive strategies. The mediation of the model problem was followed by a series of tasks that learners solved independently. Then, the procedure was repeated with the next series of Set Variations tasks. The Set Variations score is a total number of correct answers in all series of Set Variations tasks after mediation. The assessment process was essentially the same with Numerical Progressions and Organizer (verbal combinatorial reasoning tasks). These tests included the mediation of several model problems followed by the independent problem solving. The score in each of these tests is a total number of correctly solved tasks after mediation.

During the postprogram assessment, Set Variations, Numerical Progressions, and Organizer tests were given without the learning phase. The participating teachers solved all problems independently. So if the preprogram assessment was aimed at the identification of the teachers' learning potential, the postprogram assessment evaluated their mastery of the problem-solving strategies and their ability to apply them independently. In addition, teachers were given four rather complex tasks that require the identification of the discrepancy between a written description and the graphic image and correction of the description. These tasks were adopted from the IE instrument Instructions that was studied by the teachers during the training program.

The training program included 160 hr of the IE course given in 4 weeks of concentrated training, 40 hr each training week. The four training weeks were spread over a period of about 9 months, so that 2–3 months of classroom teaching separated one training week from the next. In addition to training, teachers received four coaching visits from cognitive education specialists, who observed their lessons and provided constructive feedback regarding the best way to integrate cognitive principles learned during the course into their curricular teaching.

RESULTS

Pre- and posttest results are presented in Table 1. The pretest results reflect teachers' performance after mediated learning of model tasks, whereas posttest results reflect their independent solution of similar tasks. In other words, if the pretest results are indicative of teachers' potential, the posttest results show the extent to which this potential was realized by teachers in their independent problem solving.

The teachers' potential in solving nonverbal matrix tasks (Set Variations) demonstrated at the start of the program was completely realized—the same average score that at the beginning

TABLE 1. Percentage of Correct Responses in Cognitive Pre- and Posttests (N = 80)

	Set Variations	Numerical Progressions	Organizer	IE Instructions Tasks
Pre	81.23 (16.44)	76.34 (20.31)	58.76 (18.38)	—
Post	79.44 (16.00)	83.33 (14.31)*	72.39 (21.76)**	82.19 (23.26)

Note. Average percentage of correct answers, standard deviations in parentheses. Pretest scores after mediation, posttest scores without mediation. IE = Instrumental Enrichment.

* $t = 3.57, p = .001$. ** $t = 6.11, p = .001$.

of the project was achieved with the help of mediation was achieved without mediation at the end of the project. The posttest results with number series tasks (Numerical Progressions) are slightly higher than pretest results, thus indicating that not only the initial potential was realized but some of the more complex tasks were solved independently. This result may, however, be related to the fact that number series were present in one of the IE instruments studied by the teachers. The most impressive results were achieved in verbal combinatorial reasoning tasks (Organizer). The average independent problem-solving posttest results were 0.79 *SD* higher than mediated pretest results. Teachers demonstrated significant gains in their verbal reasoning, beyond the potential identified at the pretest. Because no task in the IE program resembles Organizer, it is possible to conclude that the cognitive strategies acquired during IE training were transferred to the tasks that are rather distant from the program material.

The results also demonstrated a clear link between teachers' mastery of complex IE tasks and their performance on the cognitive posttest. The Instructions IE tasks require identification of discrepancy between the graphic image and the written description and the correction of the description. Teachers who solved all four of the Instructions tasks had a significantly higher aggregate posttest cognitive score than those who solved one or two tasks ($M = 246.1, SD = 37.5$ vs. $M = 202.9, SD = 55.1$). The difference was significant ($t = 3.23, p = .02$) and the effect size large $d = 0.96$.

The question regarding the impact of training on teachers with a different initial performance level was first addressed by calculating the Pearson correlation between pre- and posttest aggregate cognitive scores. The correlation was rather strong: $r = 0.74$. This means that on average, those teachers who demonstrated higher results under conditions of mediated problem solving also achieved higher results in independent problem solving at the end of training. This, however, does not mean that "strong became stronger while weak remained weaker" (the so-called "Matthew effect"). To evaluate the relative cognitive gain of different teachers, the following formula was used.

$$\text{Relative gain score} = \text{Actual gain score} \div \text{Possible gain}$$

(For example, if the pretest score is 50 and the maximal possible score is 100, then the possible gain is 50. If the actual gain [i.e., the difference between post- and pretest scores] is 25, then the relative gain is $25/50 = 0.5$.)

Relative gain scores (RGSs) were calculated separately for teachers with lower aggregate pretest scores and higher pretest scores, divided by a median split. It turned out that the relative gain of initially low-achieving teachers is higher ($RGS = 0.25$, $SD = 0.57$) than that of initially higher performing teachers ($RGS = 0.13$, $SD = 0.34$). Because of the very large standard deviation, the difference between groups does not reach the level of statistical significance ($t = 1.06$, $p = .29$). One may thus conclude that although there is a tendency for teachers who started the program with lower cognitive performance to have greater relative cognitive gains, this tendency did not reach the statistically significant level.

DISCUSSION

A still prevailing attitude toward classroom instruction is curriculum-based. In this theoretical context, *teachers' competence* is defined as their curricular knowledge and the ability to use content-oriented didactic skills. Although the goal of developing students' thinking skills is included into almost all national curricula, not much is known about the teachers' own cognitive skills and even less about the ways to enhance these skills. For this reason, the main objective of this study was to shed some light on initial cognitive performance of in-service teachers and the possible impact of IE program training and implementation on the improvement of this performance. Moreover, this study included the results of DA conducted before IE training, thus allowing us to compare cognitive performance of teachers with and without mediation. To the best of our knowledge, there is no other study that used a DA approach with teachers.

The present research was undertaken as a part of the practical teacher training project. For this reason, only some aspects of the project generated quantifiable data that could be used in the present research. For example, in the discussion with project staff, practically all teachers acknowledged that the DA experience was very important and made them aware of their own and their students' problem solving. These statements supported the objectives of the practical project, but because no standard questionnaire was used, it could not be used in the present research. Similarly, important practical data have been collected during classroom visits by IE coaches who reported a considerable enhancement of teachers' mediational skills. The observational scales used by coaches, however, were not standardized and for this reason, this observational data, although essential for a practical project, could not be used in the present research. The research thus focuses exclusively on the enhancement of cognitive skills of teachers who participated in the IE program, training, and implementation.

The results of the study allow some conclusions to be drawn regarding the impact of cognitive training on teachers' thinking skills. First, similarly to some earlier studies (Kozulin, 2005; Skuy et al., 1993), the results confirmed that at the beginning of the program, the cognitive performance of in-service teachers was far from reaching the "ceiling" level. Particularly in the area of verbal combinatorial reasoning, many teachers experienced significant difficulties even when model tasks and the principles of their solution were mediated to them. This indicates that some form of cognitive training is important for teachers not only as potential mentors of their students but also as individuals in need of developing their own cognitive skills.

The results of the study appear to indicate that participation in the cognitive training program significantly improved teachers' cognitive skills. The learning potential demonstrated by teachers at the start of the program was fully realized. In terms of Vygotsky's (1935/2011) concept of the zone of proximal development (ZPD), those functions that existed in teachers' ZPD at the beginning of the program became fully mastered at the end of the program. In the area that was most problematic, that of verbal combinatorial reasoning, the teachers not only realized their potential but also made significant additional gains, much greater than those reported in the Skuy et al. (1993) study of South African preservice teachers.

The issue of the teachers' mastery of IE tasks deserves a special note. It is generally presumed that these tasks intended for high school students will be mastered perfectly by their teachers. This study indicates, however, that about 47% of the participating teachers were unable to correctly solve all four Instructions IE tasks presented to them at the end of the program. There appears to be a direct relation between teachers' mastery of IE tasks and improvement of their thinking skills. Those teachers who successfully solved all Instructions IE tasks at the end of the program were also superior to their colleagues in cognitive tasks.

The final question is to what extent is cognitive training beneficial for all teachers, in other words, whether teachers who start the program with lower performance results benefit from it. The question is important in the context of the current debate regarding the so-called Matthew effect (see Ceci & Papierno, 2005). The Matthew effect points to the fact that when an educational enrichment program is given to a heterogeneous group of learners, it is often initially stronger learners who benefit most. As a result, instead of closing the gap, the gap becomes even wider. The problem of gap closing is relevant not only for school students but also for teachers. Is it possible to take a heterogeneous group of teachers and conduct cognitive training in such a way that initially weaker participants benefit more? The results of this study demonstrate that this is feasible. Although on average, teachers with initially better cognitive performance remained on top on the posttests, nevertheless, the gap closing did take place. The relative cognitive gain of initially lower performing teachers was almost twice as large as that of their higher performing colleagues (although this difference did not reach a statistically significant level).

The main limitation of this study is that it was conducted in the context of an actual teacher training project that did not allow for the involvement of comparison groups. As a result, one cannot categorically claim that the observed improvement of teachers' cognitive performance is specifically related to IE activities. Future research will have to include various comparison groups that allow for comparing the possible impact of IE with that of additional curricular training and/or alternative forms of cognitive training.

Although keeping the aforementioned limitations in mind, one may nevertheless conclude that cognitive training in IE appears to have an intrinsic value for cognitive development of in-service teachers in South Africa. This value is beyond the pragmatic goal of professional development—preparation of IE program teachers. Teachers as recipients of cognitive training gain in terms of their own cognitive self-development and fulfillment. More studies are needed, and not just in South Africa, on the possible impact of cognitive training on teachers and their own cognitive and problem-solving skills.

NOTE

1. The term “colored” is acceptable and widely used in South Africa for identifying mixed-race, mainly Afrikaans-speaking people, and is used, e.g., in South African labor statistics.

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