Babeş-Bolyai University, Cluj-Napoca
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Phd Thesis

Metacognitive Training Effects on Students Mathematical Performance from Inclusive Classrooms

- SUMMARY -

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Part I – Theoretical background

Experimental research

Learning mathematics is becoming a necessity in a modern society; the societal expectancies, as appears on school curriculums, are higher, and the learning difficulties are more obvious. The interest in designing and investigating efficiency of remedial interventions has increased. However, the number of studies investigating the effectiveness of different intervention programs to improve math performance is quite low (David & Maier, 2011).

Reviewing the literature addressing the issue of improving math performance of learning disabilities students, you can identify two main directions, namely, explicit instruction in mathematics and the intervention on general cognitive skills that support learning mathematics. As for the final document of the National Mathematics Advisory Panel (2008), interventions involving explicit systematic instruction require the teacher to explain, demonstrate specific strategies, allow students to ask and answer questions, and verbalize the resolution process. Interventions in the field of math learning difficulties can be categorized based on the psychological approach, the constructivist interventions (the students builds gradually mathematical knowledge), behaviorist interventions (model the algorithm and practice the procedure till it becomes automatic), cognitive interventions (students achieve learning strategies, and metacognitive skills to use when solving math problems), interventions that develop internal representations of mathematical concepts, and interventions based on situational learning (Wilson & Rasanen, 2008, apud David & Maier, 2011). Explicit systematic instruction is one of the behaviorist interventions, while metacognitive ones are cognitive interventions.

Although there are a great number of studies on metacognition, the learning disabilities students' field is not fully understood. Researchers as Rourke (1993), Geary (2004), Montague (1992) identified metacognition as a problematic area for learning disabilities children. Thus, some researchers assert that for learning disabilities students prediction and evaluation skills are not developed in the similar way to students without such difficulties (Garrett, Mazzocco, Baker, 2006), or even that are absent, while others argue that the main problem for learning disabilities students is not the lack of skills, but the incapacity to choose the appropriate one, and the failure to adjust it if the problem changes. In line with the schemes theory, Buchel (1990, apud Preda, 2009) postulated the existence of a dual control cognitive activity, learning and problem solving: a control through mental representations – top-down, which is counterbalanced by a voluntary perception and analysis of the problem – bottom up. Students with good school performance can be observed moving between the two control levels, leading to remarkable efficiency, each level adjusting itself, if necessary, through the influence of other levels. Learning disabilities students, however, don't achieve this double control of cognitive activity.

These students fail to plan the operations they need to solve the math tasks, show difficulties in monitoring the procedures they use, often they fail in identifying the errors they make (Lucangeli & Cornoldi, 1997). Prediction skills allows them to distinguish between the simple problems and the difficult ones, identify those that need more time, more skill and more effort to be solved. Students with good prediction skills are able to distinguish between real and apparent difficulties when predicting the performance will have. Evaluation skills help the students to reflect on the solutions and to identify the possible errors they made. If they have low evaluation skills, the monitoring skills will also be low. They won't be able to judge whether the plan they have is the correct one, or if the solution is right (Garrett, Mazzocco, Baker, 2006).

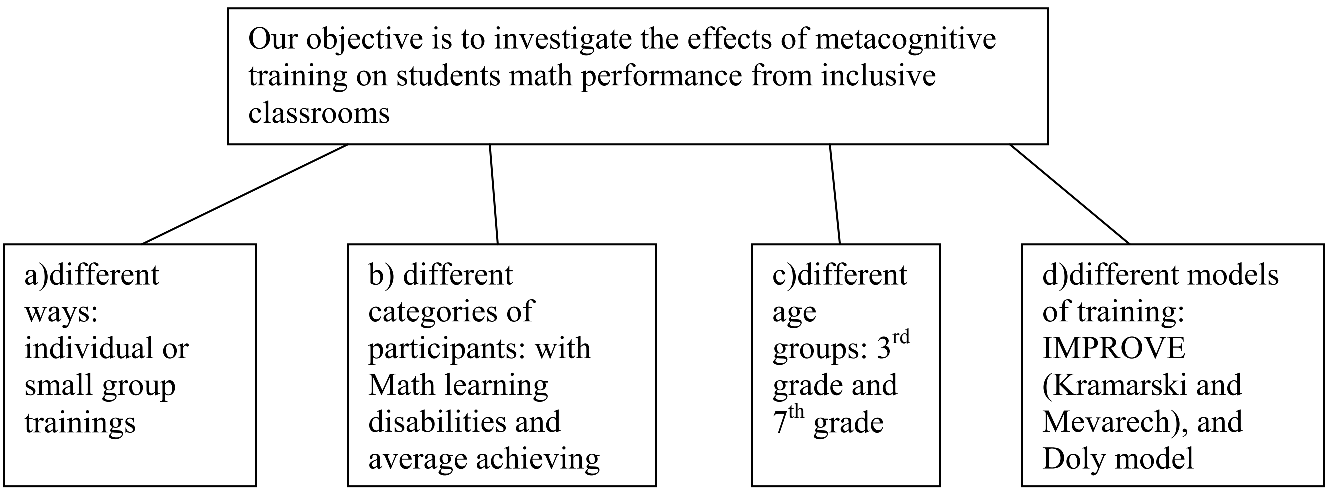
Considering the complex nature of the mathematical domain, it may be important to evaluate the metacognitive skills in order to focus on metacognitive training and its role in mathematics learning and development (Desoete, 2007). Based on the research of Annemie Desoete (2007), where the author showed that metacognitive evaluation by such a multidimensional model is necessary to elementary school students, to supplement the information from multiple sources, and is collected in different stages of evaluation, we considered it appropriate to use such a multidimensional model in metacognitive evaluation of students, even for middle school students, to get as much information, and to outline such a complete picture as possible of knowledge and metacognitive skills.

Over time many researchers have focused on metacognitive training and its potential to influence math performance, focusing on the combined method of cooperative learning and metacognitive training. Some studies showed that students exposed to individual metacognitive training may have similar or even better school performance than those exposed to metacognitive training in small groups because the students are used to analyzing the task, to build connections between the new and old knowledge, and to use appropriate strategies to solve the problems, in individual sessions, when it is assumed that students attention is not distracted by various environmental stimuli. On the other hand, others reached the conclusion that the effects of metacognitive training are enhanced by cooperative learning (Kramarski and Mevarech, 2003).

It is important to examine the effects of different learning methods on knowledge transfer. Many studies have shown that knowledge transfer skills to new situations are limited to most students. Cecil and Roazzi (1994, apud Kramarski and Mevarech, 1997) argue that training students to distinguish between the similarities and differences of problems, facilitates the ability to transfer knowledge and improve math performance. Since the '70s, when Flavell (1979) outlined the term, more research focused on the nature of metacognition processes, as it develops according to student's age and how it can be used in class. There are reasons to believe that exposure to different teaching methods can have different effects on general metacognitive knowledge, or specific ones. It is expected that students exposed to metacognitive training to be better at reflecting on the problem solving processes, than those who were not exposed to such training. Also, discussion of metacognitive questions in small groups is expected to influence the development of metacognitive knowledge and skills.

Our objective is to investigate the effects of metacognitive training on students math performance from inclusive classrooms through different approaches of metacognitive training (individual or small groups), different age students (seventh and third grade students), and also, different models of metacognitive training: the model offered by Kramarski and Mevarech – IMPROVE, and the Doly model, the method of the 4 stages.

Figure 1. General structure of research



These objectives were investigated in three studies organized on two different age levels. The first study includes a group of 64 participants, 7th grade, middle school children attending two schools in Cluj-Napoca, from 5 different inclusion classrooms. The second one includes 26 math learning disabilities students, attending the inclusion program, and the third study, a group of 24 third grade students with low math performance, selected from three inclusive classrooms.

For the first two studies, we designed a 6 months metacognitive training, based on the IMPROVE method. IMPROVE is the acronym of seven teaching steps: Introducing new concepts, Metacognitive questioning, Practicing, Reviewing, Obtaining mastery on the objective proposed, Verification, and Enrichment. For the third study, we designed a 6 weeks metacognitive training according with the Doly model, with four stages: modeling stage, teacher guided practice stage, cooperatives practices, and independent practice stage, considering it the more appropriate for the participants age level.

Even though less extensive than the previous two studies, the third one is meant to complete the first two. The metacognitive training from both, the first and second study, was administered individually or in small groups. The third study has a metacognitive training program that includes both models, each participant has a cooperative practice stage and an independent practice one. The third study is intended to bring more information on the effectiveness of metacognitive training given at an early age, where few researchers believe that we can already speak of metacognition, metacognitive knowledge and skills. Jebeli Ali (2003) considered metacognitive training as a very important technique to reduce the differences between the performance that students can achieve independently and the performance they can only achieve with help at the age of 7-11 years.

1st Study - Metacognitive training effects on mathematical performance of students without learning disabilities from inclusive classrooms

Based on data, regarding the importance of metacognitive assessment through a multidimensional model and the use of a metacognitive training to improve students math peformance, we formulated the following hypotheses:

1. It is necessary to assess metacognition through a multiple-method design to get a complete picture of it, even for seventh grade students without learning disabilities from inclusive classrooms.
2. The students without learning disabilities from the inclusive classrooms, who received an individual metacognitive training will have a better metacognitive performance than those who received metacognitive training in small groups.

3. The students without learning disabilities from the inclusive classrooms, who received an individual metacognitive training will have a better math performance than those who received metacognitive training in small group.
4. The prediction skill accuracy is improved for students who benefit from individual or small groups metacognitive training.
5. The evaluation skill accuracy is improved for students who benefit from individual or small groups metacognitive training.
6. The four metacognitive skills assessed by the student's questionnaire are good predictors of math performance for students without math learning disabilities.

Method

Participants

Subjects were 7th grade, middle school children attending two schools in Cluj-Napoca, from 5 different inclusion classrooms. They had 4 different math teachers; one teacher taught two different classrooms, but the same teacher delivered the metacognitive training to all of them, in 50 minutes sessions, once a week. The pretest was administered to a number of 64 students. After that, they were randomly assigned to one of a three groups, of which two were administered the training conditions. One was the control group. No significant differences were found between groups in the pre-test conditions.

Table 1 – Participants groups

	Students without learning difficulties
Group 1 – individual intervention	22
Group 2 – small group intervention	21
Group 3 – control group	21
Total	64

Procedure

The pre-test was administered in December and the metacognitive training was delivered in 12 sessions of 50 minutes, during January – May. The post-test was administered in June.

Measures

Mathematics measures

The mathematics knowledge test is an informal instrument developed together with one of the math teachers, based on a sixth and seventh grade curriculum and long range plans. It contains several mathematical problems, such as equations, percentages, fractions, order of operations.

Metacognitive measures

Metacognition was assessed with off-line (prospective and retrospective), and combined techniques. The Prospective Assessment of Children (PAC) and the Retrospective Assessment of Children (RAC) were used as off-line ratings for children, and Teacher Ratings were used as off-line rating for teachers. The Evaluation and Prediction Assessments were used as combined (prospective and retrospective) assessment.

Off-line techniques

The Prospective Assessment of Children (PAC) is a child questionnaire, adapted from Desoete (2007). It is a 25 item rating scale questionnaire for children on metacognitive predictions, planning, monitoring and evaluation skills. Children have to indicate before solving any mathematical problem on a 4 point Likert-type of scale what statement is representative of their behavior during mathematical problem solving (1- never, 2 - sometimes, 3 – frequent , 4 – always). The PAC scale, as well as the subscales have an adequate internal reliability. Cronbach's alpha for the PAC scale was .81 (25 items). For the PAC subscales Cronbach's alpha were .60 (9 items – prediction), .64 (4 items, planning), .76 (8 items, monitoring) and .52 (4 items, evaluation).

The Retrospective Assessment of Children (RAC) is the same 25 item rating scale questionnaire for children on metacognitive prediction, planning, and monitoring and evaluation skills. Children have to indicate on a 4 point Likert-type of scale to what statement was representative of their mathematical behavior, the last 6 months during mathematics. The PAC scale, as well as the subscales have an adequate internal reliability. Cronbach's alpha for the total score was .79 (25 items). For the RAC subscales Cronbach's alpha were .44 (9 items, prediction), .59 (4 items, planning), .73 (8 items, monitoring), .56 (4 items, evaluation).

The Teacher Rating Assessment (adapted from Desoete, 2007) is a 20 item rating scale teacher-questionnaire on metacognition prediction, planning, monitoring and evaluation skills. The PAC scale, as well as the subscales have an adequate internal reliability.

Cronbach's alpha of .91 was found for the test score (20 items). For the teacher rating subscores Cronbach's alpha were .81 (7 items, prediction), .59 (4 items, planning), .62 (6 items, monitoring), .71 (3 items, evaluating).

Combined technique

The Evaluation and Prediction Assessment is a procedure for assessing prediction and evaluation. In the measurement of prediction skillfulness, children were asked to look at the math problems without solving them and to predict on a 0-10 point scale, how they can solve it. After they solve the math problems from the knowledge math test, they are asked to evaluate their answers on the same 0-10 point scale. It was used the same 0-10 point scale, in analogy with the Romanian Evaluation System. We did a calibration score for each item, which means a difference between the math performance they had and the predictions/evaluations they did.

Description of the training program

Duration: both trainings were conducted over a six months period with once a week sessions of 50 minutes each. Sessions were conducted individually for the first group and in small groups of 4-5 students for the second one. All sessions were conducted in school, in the Resource room, apart from their classrooms.

The metacognitive training was created to improve metacognitive knowledge and metacognitive skills of students from inclusive settings. It was designed on an IMPROVE model (Mevarech and Kramarski, 1997).

The first session was an introductory one, students found out some information about metacognition, cognition, metacognitive knowledge and metacognitive skills, metacognitive trainings. We talked about the acronym IMPROVE, and the seven steps that are involved in this method. The students have to think about these seven steps, and to find an acronym in the Romanian language.

In the second session we reviewed the steps involved by IMPROVE, and we tried to define them. Each definition in Romanian language, needs to start with the correspondence letter from the English acronym:

I-Introducerea noului material (introducing the new material)

M- metacognitie (metacognition)

P- profesorul ajuta elevii in rezolvarea problemei (the teacher helps the students to solve the problem)

O – o rezolvare pe cont propriu (resolving by himself)

V – verifcarea problemei (verification)

E- elaborarea alternativelor de rezolvare (finding different ways to solve the problem).

We also tried to find a good acronym in Romanian language:

C-citirea problemei (reading the problem)

I-intrebari metacognitive (metacognitive questions)

R-rezolvarea problemei cu ajutor (solving the problem with help)

P-planul de rezolvare al problemei (the solving plan)

R-rezolvarea problemei fara ajutor (solving the problem without help)

V-verificarea problemei (verification)

A-alternative de rezolvare a problemei (finding good solving alternatives)

The third session consisted of review of the steps illustrated by the acronym IMPROVE. As was discussed in the second step; the metacognitive questions. The students are asked to come up with as many questions as they can think of when they have to solve a math problem.

In the fourth session we discussed the metacognitive questions pointed out by the students, and we identified the four types of metacognitive questions:

- Comprehension questions: questions about the problem task (What is this problem about?)
- Connection questions: questions about similarities and differences between the problems they work (How is this problem different/ similar from the previous one?)
- Strategic questions: questions about the appropriate strategies for solving the problem (Why is this strategy appropriate to solve the problem?)
- Reflection questions: questions to reflect on their understanding the solution process (Can you solve it in a different way?)

The fifth session consisted of reviewing all of the metacognitive questions found by the students, and writing them on colored posting cards. When the cards are done, students read them and divide them into 4 groups, one for each metacognitive question type.

The next sessions are designed for practicing the method on different problems, from different math book chapters.

The last session is for reviewing the method, and to underline its importance during the math solving process.

Results

Based on a research of Annemie Desoete (2007), where the author showed that the metacognitive evaluation by a multiple-method design is necessary to elementary school students, we formulated a hypothesis for the maintenance of this specific evaluation form for seventh grade students, even if it is considered that they improved their metacognitive knowledge and skills through the age. We used a correlation analysis, for each group. Significant correlations were shown between Prospective and Retrospective Children Assessment (PAC- RAC) for each experimental group, for each of the four metacognitive skills.

To investigate the effects of individual or small group metacognitive training on students metacognitive performance, an ANOVA statistical procedure was used to analyze the data obtained in pre-intervention phase for all three groups. The results showed no significant difference among groups (two experimental and the control group) before training. Further comparisons pre-test – post-test, using t test for repeated measures, showed significant differences between the two moments, for the experimental groups and insignificant for the control group.

Another ANOVA statistical procedure was used to analyze the data obtained in post intervention phase for all three groups. Because the results showed significant differences among groups (two experimental and the control group) after the training, a POST-HOC analysis (Tukey test) was further conducted. Prior to this analysis a Levene test was run to assess the equality of variances in different samples. Based on the results, we selected the Post-hoc Tukey test in order to compare each measure. For the Evaluation Assessment Test we used Tamhane test, because the Levene's one showed significant results. Results obtained show significant differences between control group and intervention in small groups on the overall score of the student questionnaire, the prospective form, and the prediction skill, measured by the same questionnaire. For the prediction skill, however, significant differences occurred in the post-test between the experimental groups, and between each of them and the control group.

For the next question of the study, investigating the effect of the metacognitive training on the mathematical performance, we used the same ANOVA procedure to analyze the data pre and post intervention, and t test for repeated measures for comparisons pre-test – post-test. The data show significant differences for the experimental groups, and no significant for the control one. For a more detailed analysis we chose a POST-HOC Tukey test, under the condition of homogeneity. Significant differences ($p < .01$) are shown between the control group and both experimental ones, for the Math Knowledge Test, but not between the experimental ones. That means individual metacognitive training and metacognitive training in small groups are both efficient, because the students improved their math performance, but there is no difference between the way of delivering the training, both being equally efficient in improving the math performance.

Since no significant differences were obtained between the two experimental groups, we considered it appropriate to continue with the effect size for each type of intervention. Thus students without learning disabilities who received an individual metacognitive training improved their math performance in a greater degree than those who received metacognitive training in small groups sessions, both groups show a strong effect size ($d > 0.8$).

For the fourth and fifth hypothesis of this study, we used a t test for repeated measures to see if the prediction and evaluation metacognitive skills have improved because of the metacognitive training received either individual or in small groups sessions. Results showed improvements in both experimental groups, for both skills. Calculating the effect size, we could see a strong effect for the prediction metacognitive skill ($d > .80$) in both experimental groups, and a medium effect size for the evaluation metacognitive skill for individual intervention group ($d = .76$), and a low one for the small group intervention ($d = .38$)

Based on existing data in the literature, indicating that the metacognitive skills measured by teacher ratings were good predictors for 3rd grade students math performance (Desoete, 2007), we came with a specific hypothesis on the predictive value of metacognitive skills assessed by the students questionnaire, on math performance. We used a linear regression analysis, for each group, the predictor variables beeing the four metacognitive skills assessed, and the criterion variable, the math performance. Just the experimental group showed significant results, in terms of predictive value of metacognitive skills. Among these skills, the prediction skill has proved a good predictor of math performance.

Analysis and intrepretation of results

Based on the correlations obtained between the metacognitive measures, we can say that assessing metacognition through a multiple-method design, including teacher questionnaire, is very important even for seventh grade students without learning disabilities from inclusive classrooms. Students questionnaire do not seem to reflect actual skills, but they are useful to get a picture of metacognitive knowledge, beliefs, skills. In addition to prospective and retrospective techniques, concurrent assessment or mixed ones should take place. Teacher questionnaires were found to have some value added in the evaluation of metacognitive skills.

Based on the results we can conclude that students can improve their metacognitive skills through either an individual metacognitive training or a metacognitive training in small groups, both being effective. Metacognitive training delivered in small groups seems to have a stronger effect on the skills measured by the students questionnaire, the prospective form, on the overall score, and on the prediction, when the individual metacognitive training on the evaluation skill, highlighted by the mixt metacognitive measurements, but the differences are not statistically significant. The only dimension where there are significant differences between the two experimental groups is the prediction test. The size effect indicates that seventh graders without learning disabilities who benefit from individual metacognitive training have better results on improving their prediction skills than those who received a small group intervention. These results contradict those obtained by Kramarski and Mevarech (1987). They have found, when using the same model of metacognitive training, that metacognitive training associated with cooperative learning is more effective than the individual one. Though contradictory, results are somewhat expected given the specific Romanian education system, where cooperative learning is not frequent used, and therefore students are not yet accustomed to work in small groups.

Regarding the intervention effect on student mathematic performance, we can say that there are significant differences only between the control group and each of the experimental groups. Even the effect size measures show us a greater improvement in math performance of students who received individual intervention, differences between the two intervention groups are not statistically significant.

The metacognitive intervention efficacy was confirmed by the prediction and evaluation improving accuracy. Both experimental groups showed improvements in the accuracy of the prediction and evaluation metacognitive skills, the prediction skill growth being higher than the evaluation one.

Thinking about the four metacognitive skills, assessed by the students' questionnaire as being good predictors of math performance, we can say that only the prediction metacognitive skill is a good predictor of math performance for the experimental group; for the control group all four of them failed as good predictors of math performance.

Based on the results we can conclude that for seventh grade students without learning disabilities from inclusive classrooms it's still important to evaluate metacognition with a multi-method design, including teacher questionnaires to get a complete picture of metacognitive skills.

Moreover, they can improve their metacognitive skills and their math performance through either an individual metacognitive training or a metacognitive training in small groups.

However the results must be viewed with caution due to the relatively small number of participants, length of intervention (only 6 months), the absence of follow-up tests to see if the training effects are maintained in time. Starting from these preliminary results, however further studies will attempt to overcome these limitations by including follow-up testing and a larger number of participants to give us greater statistical power. Also it would be interesting to see if the improvements observed in math performance can be found in other areas, such as physics, chemistry, or in the opposite fields, Romanian language and literature.

2nd Study - Metacognitive training effects on mathematical performance of students with learning disabilities from inclusive classrooms

Based on published literature and the results obtained in the previous study, we wanted to go further, by applying the same research model on a different population - seventh grade students with learning disabilities from inclusive classrooms, classmates of the students participating in the previous study.

Thus, based on the available data in the literature, emphasizing the importance of multi-method metacognitive assessment and the effect of the metacognitive training on improving students' math performance, but also the results from the previous study, we came with the following ***hypotheses:***

1. For the learning disability seventh grade students from inclusive classrooms, metacognitive evaluation by a multidimensional model is important, as a result of supplementing the information from multiple sources and at different times of evaluation.
2. The learning disabilities students from the inclusive classrooms, who received an individual metacognitive training will have a better metacognitive performance than those who received metacognitive training in small groups.
3. The learning disabilities students from the inclusive classrooms, who received an individual metacognitive training will have a better math performance than those who received metacognitive training in small groups.

4. Prediction and evaluation metacognitive skills change differently for the math learning disabilities student, than for students without learning difficulties, as a result of the metacognitive intervention.
5. Math learning disabilities students show a different metacognitive profile, as compared to those without learning disabilities (differences in the development of the metacognitive skills, assessed by the student questionnaire).

Method

Participants

Subjects were 7th grade, middle school children attending two schools in Cluj-Napoca, from 5 different inclusion classrooms. The pretest was administered to a number of 26 students. After that, they were randomly assigned to one of a three groups, of which two were administered the training conditions. One was the control group. Each group includes students with learning difficulties from each of the five classes in the study.

Table 1 – Participants groups

	Students without learning difficulties
Group 1 – individual intervention	8
Group 2 – small group intervention	8
Group 3 – control group	10
Total	26

Procedure is the same used in previous studies, pre-test, metacognitive training period and post-test.

Measures are those of the previous study: *mathematical knowledge assessment test, metacognitive measurements* (apud Desoete, 2007) *metacognitive prospective Questionnaire* - The Prospective Assessment of Chidren (PAC), retrospective *metacognitive questionnaire* - The Retrospective Assessment of Children (RAC), *metacognitive assessment made by the teacher* - Teacher Rating, *prediction and evaluation Test* - The Evaluation and Prediction Assessment - EPA.

Description of metacognitive training program

The same training, as in the previous study, was used, after the IMPROVE method, designed to improve knowledge and metacognitive skills of students from inclusive classrooms - learning disabilities students and their classmates. First group received individual metacognitive training, and the second one, metacognitive training in small groups, was associated with cooperative learning. The third group is the control group. After training, there was a post-test using the same measures as in pre-test phase.

Results

Based on existing literature that emphasized the importance of metacognitive evaluation with a multi-method design assessment for third grade students (Desoete, 2007), we formulated a specific hypothesis to preserve this form of assessment for seventh grade learning disabilities students from inclusive classrooms, especially because it is considered that learning disabled students' self-assessment is higher than their teacher's, although usually their self-assessment is lower than their colleagues ones (Garrett, Mazzocco,and Baker, 2006). A correlational analysis was conducted for each of the three groups in the study, data allowing us to observe that there are highly significant correlations between the two forms, prospective and retrospective, of the student questionnaire for all four metacognitive skills assessed.

In this study we sought a continuation of existing research, and the previous study, choosing the same IMPROVE method as metacognitive training, aiming to investigate whether students with learning disabilities from inclusive classrooms, who received individual metacognitive training will improve their metacognitive and math performance more significantly than those who received metacognitive training in small groups.

A Mann-Whitney test for independent samples was used to compare the groups in the pretest. There were no significant differences between groups in pre-test for student questionnaire, both prospective and retrospective forms, or for the prediction and evaluation tests. However, significant differences emerged in pre-test for mathematical knowledge test between the small group intervention and control group, which compels us to consider them as heterogeneous groups.

A Wilcoxon test for paired samples was used for comparisons pre and post-intervention. Significant differences emerged for the individual intervention group on the student questionnaire, the global score, and also for the prediction and planning metacognitive skills for both experimental groups. For the metacognitive mixed measurements (predictive test and the evaluation one) pre-test - post-test comparison significant differences appeared only in the individual intervention group. For small group intervention and control group the differences were not significant.

An ANCOVA procedure was used to compare the groups in post-test, ANCOVA being the only option to consider for heterogeneous groups although ANCOVA is a parametric test, and normally not used for small groups of participants. Results showed significant differences between the three groups of students on the overall score for the student's questionnaire, the monitoring and evaluation skills. Since differences occurred between the two experimental groups in post-test, we wanted to continue our investigation, calculating the effect size for student questionnaire, and the four subscales, to determine intervention's effect on each experimental group. For individual intervention group, there has been a very strong effect size (Cohen d> .80) both to the student questionnaire overall score and the four subscales. For the small groups intervention, we obtained a strong effect size to the questionnaire overall score, and for the prediction and planning metacognitive skills. For monitoring and evaluation skills, we obtained only a medium effect size (.50 <Cohen d <.80). The data obtained allows us to say that individual metacognitive training proved more effective in improving metacognitive performance measured by overall score on student questionnaire and monitoring and evaluation metacognitive skills. For the other two metacognitive skills, namely the prediction and planning, although there were differences between groups, they were not statistically significant, thus not allowing us to establish which one is more effective.

As for the metacognitive mixed assessments, namely prediction and evaluation tests, post-test comparisons made with ANCOVA show significant differences between groups only for the evaluation test. Thus, very significant differences (p<.01) were found on the evaluation test between individual intervention group and small groups intervention, and significant differences, (p<.05) on evaluation test, between individual intervention group and control group.

The third hypothesis of this study was aimed at investigating the effects of metacognitive training on mathematical performance. A Mann-Whitney test was used the compare the groups in pre-test. Results indicate significant differences between small group intervention and control group on math performance in pre-test. Therefore, we used an ANCOVA test for the post-test comparisons between groups. A pre-test - post-test comparison, using Wilcoxon test, shows us significant differences between the pre-test and post-test at each of the three groups of students.

An ANCOVA test was used to investigate the effects of metacognitive training on math performance for each experimental group. Since we obtained significant differences between the groups in post-test, we used again ANCOVA, considering pairs of groups. The results show that there are very significant differences (p<.01), on math performance between control group and individual intervention group, and significant differences ($p<.05$) between the control group and intervention in small groups. Between the two experimental groups no significant differences emerged on math performance for learning disabilities students.

Since we found a significant difference between the small group intervention and the control group in pre-test on math performance, we considered necessary to verify the effectiveness of intervention in the two experimental groups, calculating the effect size. Data shows that learning disabilities students who received individual metacognitive training improved their math performance at a far greater extent than those who received metacognitive training in small groups. Individual training achieved an effect size Cohen d = 2.25, as compared to small group intervention where an effect size Cohen d = .90 was calculated. However, both values are higher than .80, and so, considered strong effects.

To verify the fourth hypothesis of this study, I found it necessary to calculate the effect size. Data shows that accuracy of prediction metacognitive skills improved for both experimental groups, with better results for individual intervention group, where Cohen d is 2.32, compared with 1.94 for the intervention in small groups. The accuracy of evaluation metacognitive skills, also improved in both experimental groups, but mostly for individual intervention group, where Cohen's d value is 2.00, compared with 1.23 for the intervention in small groups. All values indicate that metacognitive training was very effective in improving metacognitive skills measured by the prediction and evaluation tests, as shown by their powerful effects size, all values for Cohen d. being higher .80. But if we compare the improvement of the two metacognitive skills, we can mention that the training seems more effective for prediction metacognitive skill, where the value of Cohen d = 2.32 .

The last hypothesis of this study, that math learning disabilities students have a different metacognitive profile as compared to those without learning disabilities, was invalidated. Comparison between the two categories of students in terms of standard deviation of the students questionnaire, prospective form, post-test, showed no significant differences between the profiles of learning disabilities students and those without mathematical learning disabilities in any groups of participants.

Results obtained allow us to conclude that for seventh grade math learning disabilities students from inclusive classrooms, metacognitive evaluation through a multidimensional model is still necessary in order to obtain sufficient information to outline an full array of metacognitive evaluation. And also that metacognition can be trained to secondary school students, which is in line with other results from the literature (Mevarech and Kramarski, 2003); a specific metacognitive training, having positive effects on improving metacognitive and mathematical performance. The novelty of this study consists in emphasizing that metacognitive training delivered individually is more effective than the one delivered in small groups.

However, the results should be viewed with caution. The small number of participants, and the absence of a follow-up testing for evidence of maintaining the changes resulting from intervention are just some of the limitations of this study. Starting from these preliminary results, however, further studies will attempt to overcome these limitations by including a larger number of participants to give us greater statistical power, and by inclusion of follow-up testing.

3rd Study - Metacognitive training effects on math performance of low achieving students

Although there are a lot of studies on metacognition, the number of those that investigated the effects of the metacognitive training on elementary school students is still small, maybe because it is considered that metacognition develops fully later. Desoete (2001, 2004, 2007, 2009) and her colleagues have pointed out in numerous studies that early school age students, third grade students, have valuable knowledge and metacognitive skills, that influence their math performance.

Knowing the role of metacognition in monitoring and improving academic achievement, we can assume that it is equally important in arithmetical problems that require planning, monitoring of steps and evaluation of the task difficulty. A metacognitive training will lead to improved performance in such tasks by increasing metacognitive knowledge, but also by developing, strengthening and automating of prediction, planning, monitoring and evaluation skills.

The hypotheses of this study are:

1. The low achieving students in mathematics, who received metacognitive training will have better metacognitive performance than those who didn't receive such training.

2. The low achieving students in mathematics who received metacognitive training will have better math performance than those who didn't receive such training.

3. Accuracy of the prediction metacognitive skill will not improve as much as the evaluation metacognitive skill, when given metacognitive training.

Method

Participants

Participants are third grade students in a school from Cluj-Napoca. The pre-test was administered to 72 children from 3 classrooms. Based on the calculation fluency test results we formed two groups of participants, distributed to experimental group (N = 12) and to the control (N = 12). Given the small number of participants, we chose to pair sample based on the calculation fluency performance criterion.

Procedure

A week before the training, students were tested with a calculation fluency test, math test, and a metacognitive measure. The training was delivered in 6 sessions and a week after the end of training post-test measurements were administered and participants were rewarded.

Measures

Calculation fluency test measures speed and accuracy to solve simple calculations of crossing down addition, subtraction and multiplication. It involves making a large number of correct calculations in the given order and a time unit.

Mathematical knowledge Evaluation Test

Third grade mathematical knowledge test is an informal instrument developed with the Resource teacher, based on the third grade Math curriculum and long range plans. It contains several arithmetical problems: multiple digit additions, and subtractions, multiplications by 10s, simple division, and order of operations with all four operations and round parenthesis.

Metacognitive measures

The Evaluation and Prediction Assessment (EPA) is design to assess metacognitive skills of prediction and evaluation. To measure the prediction skills students are asked to evaluate on a Likert scale of 3 (1 - no, I do not know the correct answer, 2 - I do not know, I can not assess whether or not I know the answer, 3 - yes, I know the correct answer) the capacity of solving test problems, without trying to solve them. And after solving mathematical knowledge test, students are asked to evaluate on the same Likert scale of 3, the answer to each test problems (1 - no, I did not answered correctly, 2 - I do not know, three - yes, I answered correctly). Each test contains 5 items. Each item is rated with 2 points if the prediction / evaluation of student test answer is the same with one on the knowledge test, with 1 point if the student indicates that he did not know if the correct answer and his answer is right or wrong, and 0 points if the student says it is certain that the correct answer / wrong and the answer is contrary to prediction / evaluation.

Description of the metacognitive training

The metacognitive training was created to improve knowledge and metacognitive skills of students with low achievement in math. It was designed after the Dolly model (1997, apud Glava, 2009). It took place over a period of 3-4 weeks, with two weekly sessions of 50 minutes. Meetings were conducted in small groups of 4-5 students to facilitate discussion, interventions and contributions of students. All meetings were held in schools, in the Resource room, outside of their regular classrooms.

The first session training was an introductory presentation and discussion of Doly training model, with its four stages: the modeling stage, teacher guided practice stage, cooperative practice stage, and independent practice stage.

During *the second meeting* we discussed the importance of metacognitive questions on which each of the four stages is based, and have noted examples of similar questions on colored cards (what is given and what is required?, What strategies are most suitable for solving Ex. / problem ?, How does it resemble / differ from this example. / previously resolved the problem?, I will be/not able to solve without help, how can I check the result?, There is another way to solve?, What is the most effective way of solving ?).

On the *third meeting* we discussed in detail the modeling stage and the teacher guided practice, their importance, their progress, exemplified on a problem from the manual. In the *fourth meeting* we discussed cooperative and autonomous practice stages, their importance, their development with a concrete example from the manual. And the *fifth session* involved practicing the model on different examples of mathematical problems.

Results

Considering the importance of metacognition in monitoring and improving academic achievement, the first hypothesis made in this study was that students with low achievements in mathematics, who received metacognitive training will have better metacognitive performance than the control group.

Results show no difference among groups before the training. A Wilcoxon test, for comparisons of pre-test – post-test, revealed significant differences between the two moments for the experimental group, but insignificant for the control group. Post-test comparisons for the two groups, based on non-parametric Wilcoxon test, revealed significant differences between groups in favor of the experimental group, showing the effect of the intervention. Thus, the training effect is expressed by improving metacognitive performance.

For the second hypothesis, investigating the effect of the metacognitive training on the math performance, we used the Wilcoxon test for comparisons the groups in the pre-test and post-test .In the pre-test there were not significant differences between the two groups in terms of math performance. Comparisons of pre-test - post-test, using Wilcoxon, revealed significant differences between the two moments, for the experimental group, but insignificant in the control group.

Post-test comparisons for the two groups, based on non-parametric Wilcoxon test, revealed significant differences between groups in favor of the experimental one, so for the effect of the intervention. We calculated the effect size to see how these students improved their math performance, after the intervention. The results show a strong effect size (Cohen $d > 0.80$) in terms of improving mathematical performance of the experimental group.

Analysis and interpretation of results

Based on the results, we can conclude that students with low achievements in mathematics benefit from such a metacognitive training program under Dolly model (Glava, 2009), improvements in both mathematics and metacognitive performance are noticed.

Regarding the metacognitive skills assessed, there have been improvements for both, the prediction and the evaluation metacognitive skills; comparing the improvements, we can say that the accuracy of prediction increased more than the evaluation one. This may be due to the fact that the training itself specifically trained in a lesser extent the evaluation metacognitive skill.

Results indicate that metacognition can be trained in elementary school children, which is consistent with other results from the literature (Desoete, 2007), and that improving metacognition mathematical performance. However, these results should be viewed with caution due to the small number of participants, and lack of follow-up analysis. Based on these preliminary results, future studies will attempt to overcome these limitations by including a larger number of participants to give us greater statistical power.

General Discussion and Conclusions

In the present study, we wanted to clarify the role of metacognitive training on mathematics performance of students from inclusive classrooms, students with or without learning difficulties.

Considering the importance of the metacognitive assessment by a multi-method evaluation model to third graders, to get a complete picture of it, we considered important to see if it's important to use the same model for secondary school students, namely seventh grade. It is assumed that the metacognitive skills, initially involved in the particular context of each task, at the age of 10-14 years, reach a higher level of development, becoming less dependent on the context of a particular task, as students achieve more. We chose the model proposed by Desoete, (2007) that includes offline metacognitive measures, prospective and retrospective metacognitive questionnaire (completed by students) and teacher ratings, online metacognitive measures (think aloud protocol, systematical observation of metacognitive skills), and combined metacognitive measurements (prediction and evaluation tests). The model was translated and adapted for the Romanian population, keeping only the offline and mixed forms that have adequate reliability.

The hypothesis of preserving the multi-method evaluation metacognitive model, recommended by Desoete (2007) for third graders, was confirmed for seventh graders, from inclusive classrooms, students with or without learning difficulties. In both studies, significant correlations were obtained only for the Student Questionnaire prospective and retrospective forms. Information obtained from the Teacher ratings, the prediction and evaluation tests, are useful in outlining the full picture of metacognitive assessment at this age, through the extra information they provide. Even at this age, namely, in seventh grade, when it is considered that metacognitive skills are more developed than at elementary school level, it is still necessary to obtain information from various sources (student questionnaire, teacher questionnaire) and different ways of collecting data (prospective and retrospective), underlining the need to assess metacognitive skills of prediction and evaluation in concrete situations, enabling students to form a clear picture about the possibilities of solving a task and assessing the quality of the solution.

Based on research of metacognition, that emphasizes the importance of metacognitive training in improving math performance, it was considered appropriate to investigate the effects of the metacognitive training on math performance for seventh grade students from inclusive classrooms, students without learning disabilities (Study 1) and those with learning difficulties (study 2). For the research, a metacognitive training under IMPROVE method (Kramarski and Mevarech, 1997) was designed and administered to two experimental groups. The first group received an individual intervention, and second one a small group intervention.

About the effects of the metacognitive training on the metacognitive performance of seventh grade students, we can say that both ways of training delivery proved effective for both categories of participants. For students without learning disabilities significant differences between intervention methods appeared only for the prediction test, showing that the most effective is the metacognitive training in small groups. But, as these differences are not maintained for the other metacognitive measurements, it is difficult to conclude that for students without learning difficulties there would be major differences in how training is administered. This could be beneficial, especially looking at it in terms of the economy of resources, both material and human. Thus, if individual metacognitive intervention could achieve the same results as a small group one, its administration would be beneficial in small groups, even in terms of time required for intervention.

For students with learning difficulties, however, there are significant differences between intervention methods. Thus, for the student questionnaire overall score, prospective form, the monitoring skill subscale, the evaluation skill subscale, but also for the evaluation test, there were significant differences in post-test between the two methods of intervention, the individual one proved more effective for students with learning difficulties. This output can be explained by several factors such as limited environmental distractor sources in the individual training in the resource room, or more attention from the teacher.

As for the effects of metacognitive training on mathematical performance however, no differences were obtained between the types of metacognitive intervention in the two categories of students, with or without learning difficulties. There were not significant differences between the two ways of metacognitive intervention, although the effect size calculated in this case shows a larger increase in math performance for individual intervention compared to small groups intervention for students without learning difficulties and the learning disabilities students. These results are contradictory to those obtained by Kramarski and Mevarech (1997), who by using the same method of metacognitive training, administered either individually or in small groups, have shown that administering training in small groups associated with the cooperative learning, was more effective than the individual training. It should be noted however, that in the study suggested, IMPROVE method metacognitive training was administered by the math teacher during mathematics classes, targeting a specific learning unit. Therefore, metacognitive experience is not as intense in terms of allotted time, and attention to adapting content to student needs. Since the difference between the groups is not statistically significant it cannot be concluded that in terms of the mathematical performance obtained, one of the two ways of training would be more effective than the other.

The hypothesis on improving accuracy of prediction and evaluation skills through the metacognitive training administered both individually and in small groups was fully confirmed. Both experimental groups, individual and small groups interventions, for learning disabilities students and their peers without such difficulties from inclusive classrooms, improvements were recorded both for accuracy of prediction skills, involving anticipating results of resolution action and task difficulty estimation, and to the evaluation skills, which included measures for assessing the effectiveness of the work strategy / browsing solving steps. Regarding the two issues covered by the prediction strategy, anticipation of resolution action and task difficulty estimation, it was not intended to identify improvement on each component of the prediction skills. However, it would be interesting to study this aspect in future research. When comparing the improvements of two metacognitive skills, we obtained that the accuracy of prediction improved more than for the evaluation skills. In other words, after the metacognitive training, students were able estimate more accurately the difficulty of complex exercises and appreciate their resolution. This may be due to the fact that the training itself specifically trained in a lesser extent the evaluation skills. Probably it would be wise to insist on developing the evaluation skill to a greater extent in the design of future metacognitive training program.

The hypothesis that for math learning disabilities students, the prediction and evaluation metacognitive skills change differently from students without learning disabilities as a result of training administration, is partially confirmed. If we look at results, the effect size for the two skills, prediction and evaluation to learning disabilities students compared to students without learning difficulties, we can say that students with learning disabilities seem to benefit more from the metacognitive training. For learning disabilities students the prediction metacognitive skills improved more than the evaluation metacognitive skills, as evidenced by the analysis of the effect size, values measured by the Cohen d coefficient, but both are higher values than those for students without learning difficulties. For both students' categories, we noticed a greater effect size for both metacognitive skills measured to students who received individual intervention, compared with those who received the intervention in small groups.

The last hypothesis of the second study, that students with mathematical learning difficulties present a different metacognitive profile from those without such difficulties, we can say it is invalidated. Comparison between the two categories of students in terms of standard deviation for student questionnaire, prospective form of post-test showed no significant differences between the profiles of students with learning disabilities and those without mathematical learning disabilities in any of the groups of students participating in this study. This is something we consider important to note for future research, that is not possible to shape a different metacognitive profile for learning disabilities students. Failing to identify a metacognitive profile may be due to the existence of a broad range of problems that fall under the category of learning disabilities, and the many manifestations of their daily experiences. These results indicate that is important to consider each case individually, and to develop individualized educational plans that address their specific learning needs.

Regarding the last hypothesis of the first study, that the four metacognitive skills assessed by the student questionnaire are good predictors of mathematical performance for students without learning disabilities in mathematics, it was found that only for the experimental group, the prediction skill is a good predictor of math performance, while for the control group, the four skills assessed, failed as predictors of math performance.

Contrary to existing literature data (Desoete, 2007) evaluation skill as measured by student questionnaire is not a good predictor of mathematical performance. Although both mentioned study and our research addressed the predictive role of the evaluation skill, data collection sources were different. So while in our case the data was collected from the answers given by students, in Desoete (2007) data was provided by teachers (teacher ratings).

Considering that the prediction metacognitive skill has proved as good predictor of math performance, it could be a good starting point for further research to determine whether a specific metacognitive training, targeted on specific skills could have beneficial effects on converting them in good predictors of mathematical performance; it would also be interesting to study other factors that could become good predictors of mathematical performance.

The results for the third study, leads us to conclude that third-grade students with low achievement in mathematics, from inclusive classrooms, benefit from a metacognitive training program, although some researchers believe that at this age it is too early to talk about metacognition, however, the experimental results obtained both in metacognitive and math performance, confirm the hypothesis.

As for the metacognitive skills assessed on the third graders, there were improvements both for the prediction skill, which ask for the prediction of resolution action and task difficulty estimation, and the evaluation skill which included measures for assessing the effectiveness of work / browsing steps in solving strategy. If we compared the improvements of two metacognitive skills, we see that accuracy of prediction metacognitive skill improved better than the evaluation one. These results are consistent with results of 1st and 2nd studies, although it used a different metacognitive model (in the first two studies we used the IMPROVE method model and in the 3rd one, Doly model). In other words, receiving the metacognitive training, students became able to estimate more accurately the difficulty of complex exercises, and to appreciate its' solution. This may be due to the fact that the training itself specifically trained to a lesser extent the assessment strategy.

Conclusions

The results of this research indicate that metacognition can be trained to students from inclusive classrooms, students with or without learning difficulties, both for elementary and secondary schools, and that the metacognitive development improves mathematical performance.

Personal contributions in research

A first contribution of the present research is made by translating and adapting a multidimensional model of metacognitive research, which proved useful for complex evaluation of students from inclusive classrooms.

A methodological contribution is emphasizing the importance of multidimensional evaluation of metacognitive skills of students from elementary schools, both students with learning difficulties and their peers without difficulties, from inclusive classrooms. Thus it appears the need to obtain data from different sources - student questionnaire, teacher questionnaire, and different ways of collecting data - offline and mixed.

Another practical contribution lies in the specific design of two metacognitive training programs that have proved effective, IMPROVE method and Dolly model, one for seventh graders, and one for the third. The two training models can be found in the literature, but presented in a general way, the contribution of this paper is that they were adapted, customized for the groups age surveyed and specific for mathematical tasks, in accordance with the existing curriculum.

Another contribution of this study is that, comparatively, the same training had different effects on metacognitive performance for learning disabilities students compared to their classmates from inclusive classrooms. For those with mathematical learning difficulties, individual metacognitive intervention proved more effective than small groups intervention. This differentiation was not observed for students without learning difficulties, from the same inclusive classes. It is advisable to consider this when planning and designing remedial education activities, because for students with learning difficulties in mathematics, individual interventions proved significantly more effective for developing metacognitive skills than those in small groups. However, although there are differences between the two groups of students we could not outline their different metacognitive profiles; differences between the standard deviation of four metacognitive skills as assessed by the student questionnaire, for the two categories of students, were not statistically significant.

As for the effects of the metacognitive training on mathematical performance, differences between the types of intervention, individual or in small groups, were not significant, both for students with learning difficulties in mathematics, and for those without such difficulties from inclusive classes.

Limits and new lines of research

Results of this research should, however, be regarded with caution due to the relatively small number of participants, relatively low length of training and the absence of follow-up tests to see if the effects obtained after training are maintained. We will try to overcome these limitations on subsequent studies, by including a larger number of participants to give us greater statistical power, and the inclusion of follow-up testing. It would also be interesting to see whether metacognitive strategies developed through a metacognitive training specific to the mathematics could be transferred to other areas, such as physics, chemistry, or in opposite areas such as the Romanian language and literature.

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