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METACOGNITIVE TRAINING EFFECTS ON MATHEMATICAL PERFORMANCE OF LEARNING DISABILITY STUDENTS FROM INCLUSIVE CLASSROOMS

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ABSTRACT. In the current study we investigate the effects of a metacognitive training on LD students math performance. It's known as metacognitive training may influence the school math performance, but there is not enough research on the metacognitive training of learning disability students. The participants were 7th grade students from two different inclusion schools who were randomly into one of the three groups. First group received an individual metacognitive training, the second one a metacognitive training combined with the cooperative learning and the third one was the control group.

Keywords: *metacognition, training, learning disability, math performance*

ZUSAMMENFASSUNG. Metacognitive Ausbildungswirkungen Auf Die Mathematische Leistung Den Lernbehinderte Studenten Aus Inklusiven Klassenzimmern. In der aktuellen Studie untersuchen wir die Auswirkungen einer metakognitiven Ausbildung auf der Mathe Leistung von lernbehinderten Studenten. Es ist bekannt, dass metakognitive Ausbildung die schulische Mathe Leistung beeinflussen kann, aber es gibt nicht genug Forschung über die metakognitive Ausbildung von Lernbehinderten Studenten. Die Teilnehmer waren Schüler der 7. Klasse aus zwei verschiedenen Inklusionsschulen, die zufällig in einer der drei Gruppen waren. Die erste Gruppe erhielt eine individuelle metakognitive Ausbildung, die zweite eine metakognitive Ausbildung, kombiniert mit dem kooperativen Lernen, und die dritte war die Kontrollgruppe.

Schlüsselwörter: *Metakognition, Ausbildung, Lernbehinderung, Matheleistung*

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INTRODUCTION

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, Desoete, 2001, 2004, 2009, Kramarski & Mevarech 2003, Maier 2009, 2011, 2016, Mevarech 1999, Mevarech, Kramarski 2003, Mevarech, Fridkin 2006, Montague & Bos 1990, Montague 1992).

Based on published literature and the results obtained in the previous study (Maier, 2011), 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, learning disability students 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 with 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.

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.

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 METACOGNITIVE TRAINING PROGRAM

The same training, as in the previous study, was used, after the IMPROVE method (Mevarech and Kramarski, 1997), 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.

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 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, ANALYSIS AND INTREPRETATION OF 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.

Table 2. Comparing PRE-TEST student *questionnaire* prospective form (a)– Mann-Whitney

	Group 1- Group 2		**Group 1- Group 3**		**Group 2 – Group 3**	
	Z	p	Z	p	Z	p
Pre-test student *questionnaire*, form a	-.48	.63	-.62	.53	-.45	.65
PCEa_prediction	-.38	.70	-.91	.36	-.55	.58
PCEa_planning	.00	1.00	-1.03	.30	-1.17	.24
PCEa_monitoring	-.27	.79	-.76	.44	-.36	.72
PCEa_evaluation	-.16	.87	-.63	.52	-1.12	.26

Note: **, p<.01, *, p<.05

Table 3. Comparing PRE-TEST student *questionnaire* prospective form (b)– Mann-Whitney

	Group 1- Group 2		**Group 1- Group 3**		**Group 2 – Group 3**	
	Z	p	Z	p	Z	p
Pre-test student *questionnaire*, forma b	-.95	.34	-.09	.92	-.85	.39
PCEb_prediction	-.90	.36	-.36	.71	-1.49	.13
PCEb_planning	-.49	.62	-1.68	.09	-1.71	.08
PCEb_monitoring	-.54	.59	-.45	.65	-.90	.36
PCEb_evaluation	-.54	.59	-.96	.33	-.23	.81

Note: **, p<.01, *, p<.05

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.

Table 3. Comparing PRE-TEST
metacognitive measurement mixte– Mann-Whitney

	Group 1- Group 2		Group 1- Group 3		Group 2 – Group 3	
	Z	p	Z	p	Z	p
Pre-test PREDICTION	-.90	.37	-1.75	.08	-1.74	.08
Pre-test EVALUATING	-.84	.40	-.89	.37	-1.47	.14
Pre-test SOLVING	-1.22	.22	-1.69	.09	-2.62	.01

Note: **, p<.01, *, p<.05

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.

Table 4. Comparing PRE-TEST student *questionnaire*
prospective form (a) – pre-test – post-test ld students (Wilcoxon)

LD students	**Group 1- indiv. intervention**		**Group 2- group intervention**		**Grupul 3- control**	
	Z	p	Z	p	Z	p
Pre-test student *questionnaire* form a Post-test student *questionnaire* forma a	-2.04*	.04	-1.53	.12	-1.07	.28

Note: *, p<.05

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.

Table 5. Metacognitive mixed measurements (predictive test and the evaluation one) pre-test - post-test comparison LD students (Wilcoxon)

LD students	**Group 1- indiv. intervention**		**Group 2- group intervention**		**Grupul 3- control**	
	Z	p	Z	p	Z	p
Pre-test PREDICTION Post-test PREDICTION	-2.24*	.02	-1.82	.06	-.92	.35
Pre-test EVALUATION Post-test EVALUATION	-2.21*	.02	-1.83	.06	-1.74	.08

Note: **, p<.01, *, p<.05

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.

Table 6. ANCOVA, post-test, student *questionnaire* prospective form

	F	**p**
Post-test student *questionnaire* prospective form	22.49**	.00
PPCEa, prediction	.15	.70
PPCEa, planning	1.44	.24
PPCEa, monitoring	16.75**	.00
PPCEa, evaluation	21.35**	.00

Note: **, p<.01, *, p<.05

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.

Table 7. Effect size for student questionnaire, prospective form

Effect size for student questionnaire – **LD students**	**Group 1 (indiv. interv.)**	**Group 2 (small groups interv.)**
	d Cohen	d Cohen
Post-test student questionnaire, prospective form	1.81	1.50
PPCE_prediction	1.18	2.04
PPCE_planning	1.83	0.89
PPCE_monitoring	1.02	0.51
PPCE_evaluation	1.47	0.63

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.

Table 8. ANCOVA- metacognitive mixed assessments in post-test

POST-test	**F**	**p**
PREDICTION test	.32	.57
EVALUATION test	9.29	.00

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.

Table 9. Comparing PRE-TEST math performance – Mann-Whitney

	Group 1- Group 2		Group 1- Group 3		Group 2 – Group 3	
	Z	p	Z	p	Z	p
Pre-test – Math knowledge test	-1.22	.22	-1.69	.09	-2.62*	.01

Note: **, p<.01, *, p<.05

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.

Table 10. Effect size, PREDICTION and EVALUATION, LD students

Effect size – LD students	**Group 1 (indiv. interv.)**	**Group2 (small groups interv.)**
	d Cohen	d Cohen
PREDICTION	2.32	1.94
EVALUATING	2.00	1.23

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.

CONCLUSION

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.

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