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Gender, abilities, cognitive style and students' achievement in cooperative learning

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Abstract: The purpose of the study was to investigate the effects of cooperative learning on achievement in mathematics and native language and to analyze students' achievement in cooperative learning according to their gender, abilities and cognitive style. Three hundred and seventy three (170 in the experimental and 203 in the control group) fifth grade students from nine different primary schools participated in the study. In experimental group, cooperative learning was introduced in one quarter of the hours dedicated to mathematics and Slovene language during the school year. Control group received the traditional way of teaching in both courses. The results were analyzed with ANOVA. Positive effects of cooperative learning were found in both courses. Results in cooperative learning group were further analyzed according to students' gender, abilities and cognitive style. No significant interaction between students' achievement and their gender or abilities were found. Statistically significant interactions between students' cognitive style and achievement were found in both courses. Field-dependent students benefited most from cooperative learning.

Key words: gender, abilities, cognitive styles, cooperative learning, achievement, students

Spol, sposobnosti, kognitivni stil in dosežek učencev pri sodelovalnem učenju

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Povzetek: V raziskavi smo želeli proučiti vplive sodelovalnega učenja na dosežek pri šolskih predmetih matematika in materinščina ter analizirati dosežke učencev s sodelovalnim učenjem glede na spol, sposobnosti ter kognitivne stile. Sodelovalo je 373 učencev petih razredov iz devetih različnih osnovnih šol, 170 v eksperimentalni in 203 v kontrolni skupini. V eksperimentalni skupini je bilo tekom šolskega leta vpeljano sodelovalno učenje pri četrtini ur, posvečenih učenju matematike in materinščine. Kontrolna skupina je ves čas pri obeh predmetih delala po klasični metodi učenja. Rezultate smo analizirali z analizo variance. Pozitivni učinki sodelovalnega učenja so se pokazali pri obeh predmetih. Rezultate skupine, ki je delala po metodi sodelovalnega učenja, smo nadalje analizirali glede na spol učencev, njihove sposobnosti ter kognitivne stile. Nismo našli nobenih pomembnih interakcij med spolom ali sposobnostmi ter dosežki učencev, pač pa se je tako pri matematiki kot pri materinščini pokazala pomembna interakcija med njihovim kognitivnim stilom in dosežkom. Učenci s kognitivnim stilom

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odvisnosti od polja so največ pridobili s tehniko sodelovalnega učenja.

Ključne besede: spol, sposobnosti, kognitivni stil, sodelovalno učenje, dosežki, učenci

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Research on different instructional approaches in the classroom have revealed that cooperative learning in comparison with other approaches (individualistic or competitive) can have a positive influence on several areas of student functioning: on their knowledge and achievement in different subjects, on their motivation, attitudes toward subject matter, anxiety, self-esteem and social relations (Burron, James & Ambrosio, 1993; Johnson & Johnson, 1990; Lazarowitz & Karsenty, 1990; Nichols & Miller, 1994; O'Donnell, Dansereau, Hall & Rocklin, 1987; Sharan & Shaulov, 1990; Slavin, 1987, 1991).

The term cooperative learning refers to a variety of instructional methods in which teachers encourage students to cooperate in learning (Slavin, 1987). At the centre of these methods is cooperative student - student interaction. According to the equity and mutuality in the interaction we can distinguish between peer tutoring, cooperative learning and collaborative learning (Damon & Phelps, 1989), but the phrase cooperative learning is usually used for all three of them. Cooperative methods can be distinguished from each other significantly in several aspects: in the size of the group and group composition, in the way interdependence among group members is structured, in their individual accountability in the externally imposed task structure, and in the cooperative skills that group members need to perform the task.

The research to date has predominately focused on cognitive processes, and the outcomes of student knowledge as the result of cooperative learning in comparison with individualistic learning or learning in competitive situations. In their meta-analysis Johnson, Maruyama, Johnson, Nelson and Skon (1981) analysed the results of 122 studies that compared cooperative learning with other modes of learning. In the majority of studies, cooperative learning led to better results than competitive and individualistic learning. These results have been found in different subjects (language, mathematics, science, arts) in different age groups (primary school, secondary school, university), and for different tasks (concept development, problem solving, learning new material). Similar findings were reported in Slavins's (1983) meta-analytic study which also attested to the advantage of cooperative learning over individualistic or competitive learning. In addition he observed that interdependence achieved through a combination of individual accountability and having a group goal was a necessary condition of these advantages. Positive results of cooperative learning in comparison with competitive learning were also found in more recent meta-analytic study (Qin, Johnson & Johnson, 1995) for both verbal and non-verbal tasks (i.e. tasks that can be solved by the use of figures, mathematical formulas, symbols, and activities and ma-

terials used in real life situations), and for both well-defined tasks (the tasks where the procedures of problem solving, and goals are defined, for example: chess, mathematical problems) and ill-defined tasks (such as open-ended problems that require creative ways of problem solving, e.g. writing an essay).

Learning interaction and outcomes in cooperative learning can be influenced by differences among group members. The interaction in the group can be smothered by the size or composition of the group. According to Kagan (1989), the most appropriate number of group members is four: with an increasing number of group members there is a greater possibility that one or more members will not participate. The interaction is also affected by individual differences of group members in terms of abilities, perceived status in the group, cognitive style, introversion – extraversion, and socially based differences, e. g. gender differences (Cohen, 1994; Hall et. al., 1988; Webb, 1980, 1982, 1992; Wiegmann, Dansereau & Patterson, 1992).

Students' gender can influence interaction in cooperative learning groups when groups are not balanced according to this variable. Webb (1982, 1989) found gender influence on interaction and achievement in sixth and seventh-grade students in mathematics. In groups with girls in majority, girls allotted most of their messages to boys and they had lower achievement than boys. In groups where boys were in majority, boys showed the tendency to ignore girls and at the same time boys had higher achievement. It was also found that there is a higher possibility to get an elaborate answer and explanation when the question is directed to a girl. These differences were not found in the groups of students that were balanced according to gender. Petersen, Johnson & Johnson (1991) found similar results for sixth-grade students in science. In groups, balanced according to gender, there were no differences in achievement, group interaction, and perceived status. But boys got higher results in predominantly female groups and girls achieved higher results in predominantly male groups. Boys in female groups also got more instructions how to finish a task than boys in male groups.

Garduno (2001) investigated gender differences in cooperative problem solving in gifted students. She found no statistically significant differences in achievement or self-efficacy in seventh- and eighth-grade students in mathematics in single- or mixed-gender groups. But females from mixed-gender groups reported better attitudes towards mathematics than females from single-gender groups at the end of the study. Females from mixed-gender groups also reported better attitudes toward mathematics than males from mixed-gender groups.

Students' abilities are next variable that can affect group interaction and the outcomes of cooperative learning. The majority of research showed that learning in cooperative groups can be beneficial to high, medium, and low ability students (Amaria, Brain & Leith, 1969; Cohen, 1994). O'Donnell & Dansereau (1992) found that students in heterogeneous ability dyads had higher achievement than students who learnt in homogeneous ability dyads. Krajnik (2002) found no differences in achievement in seventh grade students who learned chemistry with computer based cooperative learn-

ing in homogenous- or heterogeneous-ability pairs. Barrett (2000) found higher achievement in sixth grade students who learned in heterogeneous pairs and in homogeneous high-ability pairs in computer-based cooperative learning instruction, but lower achievement in homogenous low-ability pairs.

Webb (1980) and Swing & Peterson (1982) found positive influence of group heterogeneity for high- and low-ability students, but not for medium-ability students. Bain & Lemke (1971) found that heterogeneous groups are better for students with high abilities than for students with low abilities. When interpreting these inconsistencies in the research results one has to consider the characteristics of interaction in heterogeneous and in homogenous groups. Webb (1982, 1989, 1992; Webb & Cullian, 1983) found that in heterogeneous groups students with high abilities contribute more ideas and explanations than in homogenous groups; in heterogeneous groups there is a higher possibility for the students with high and low abilities to get an answer to their question than in homogenous groups; in heterogeneous groups with small differences in abilities, there is higher possibility for the students with medium abilities to get an answer to a question, than in groups with large spread in abilities; in homogeneous groups there is a higher possibility that no one answers the question than in heterogeneous groups. The interaction in cooperative groups can be also influenced by the students' personal traits and cognitive style. Extraversion - introversion is related to the mode of help that is received in the group. Extravert students in the comparison with introvert students obtained more elaborated answers and explanation. Introvert students were, in the comparison with extrovert students, overlooked more often (Webb, 1992).

O'Donnell and Dansereau (1992) found the relationship between students cognitive style and their achievement in cooperative learning. Students were more successful in learning when they have learnt dyads that were heterogeneous according to field dependence/independence cognitive style. Druyan & Levin (1995) found that field-dependent and field-independent students interact differently in cooperative learning groups. Field-independent students contributed more to cognitive level of group functioning: they gave more simulations, analogies and problem formulations. Field-dependent students contributed more to social level: they asked more questions, they stimulated clarifications and cooperation in the group.

The purpose of the study was twofold. The first purpose of this study was to investigate the effects of cooperative learning (Kagan's structural approach) versus traditional (individualistic) learning on students' achievement in mathematics and Slovene language. Kagan's (Kagan, 1989, Kagan & Kagan, 1994) structural approach was selected because his model is based on five key elements: learning in heterogeneous groups, promoting interdependence of group members and their individual accountability, developing social skills and using different methods to structure interaction in learning situation. This model was also the most consonant with Slovene school practice that was predominantly directed to traditional, individualistic learning. Although the research findings on group composition and student achievement in

cooperative learning are not consistent, it seems that carefully balanced groups according to students' abilities, gender, and other differences are the best solution. Therefore, the second purpose of the study was to find out the differences in students' achievement according to their gender, abilities, and cognitive style (field dependence/independence), when students were learning in the heterogeneous small groups.

Method

Participants

373 students who attended the fifth grade of primary school participated in the study. The sample was drawn from nine different Slovene primary schools. 170 (90 female and 80 male) students participated in the experimental group (EG) and 203 (104 female and 99 male) students in the control group (CG). Students mean age was 11.3 years at the beginning of the experiment. In the study we used a quasi-experimental design. The schools across EG and CG were matched according to district (e.g. town or rural area) and school size (number of classes). When possible a class for EG and a class for CG was drawn from the same school. Teacher in EG and CG were also matched in age and experience (years of teaching).

Materials

Four teacher made-tests - two mathematics tests and two tests of Slovene language - were applied in EG and CG classes, to measure students' achievements. Mathematics Test 1 and Slovene Language Test 1 were used at pre-test and Mathematics Test 2 and Slovene Language Test 2 were used at post-test. Each correctly solved task was scored with 1 point. Cronbach α coefficient was calculated for each test.

Mathematics Test 1: The test for the 4th grade consisted of 18 tasks that covered understanding of basic mathematics concepts (e.g. which of the following measures is a square measure: dl, kg, mm, m^2), calculations (e.g. 845 : 25 = ___), measures transformation (e.g. How many cm is 80 m 6 dm 3 cm?) and problem solving tasks (e.g. A garden has the shape of the square; each of its sides is 11 meters long. We want to fence it with a net. How many metres of net do we need?). The Cronbach α coefficient of reliability was 0.79.

Mathematics Test 2: The test covered subject matter learnt in the 5th grade and was given at the end of the experiment. It consisted of 35 tasks (basic concepts, measure transformation, calculations, problem solving tasks). The Cronbach *a* coefficient of reliability was 0.83.

Slovene Language Test 1: The 4h grade test, consisted of 44 tasks covering grammar: use of prepositions (e.g. with (s, z), from (iz, z), to (h, k)), punctuation marks (e.g. use of , . ! ?), sentence analysis (e.g. identifying predicate, subject, ob-

ject). The Cronbach *a* coefficient of reliability was 0.85.

Slovene Language Test 2: The test covered curriculum content for the 5th grade: orthography, word analysis (e.g. identifying verbs, nouns, adjectives) and sentence analysis. The test contained 52 tasks. The Cronbach α coefficient of reliability was 0.93.

Students' abilities were measured with Figure Reasoning Test - FRT (Daniels, 1971) adapted and standardised for the Slovene population. Test included 45 figural tasks. Each task consisted of a 3x3 matrix representing a certain rule or pattern. The last element in the matrix was missing. Subjects had to choose the appropriate element among six given alternatives. The test measured general (g) intelligence. Saturation with *g* factor was over 0.80. Reliability measured with split-half method was 0.96, with test-retest method (after two weeks) 0.97 and (after one year) 0.89 (Daniels, 1971). Filed dependence/independence cognitive style was assessed with Group embedded figure test - GEFT (Oltman, Ruskin & Witkin , 1982). Test comprised 18 complex figures. Subjects had to find simple figures in the complex ones. The result was a number of correctly found simple figures. Reliability measured with split-half method was 0.79 for men and 0.82 for women (Niaz, 1989).

Procedure

Cooperative learning (Kagan's structural approach) was introduced in the EG in one of four lessons per week from October 1994 till May 1995 in two courses: mathematics and Slovene language. Students in the CG were taught in both courses in the traditional (individualistic) way. Students in EG classes were assigned to heterogeneous groups (according to their achievement and gender). Groups were changed twice during the experiment to allow students to have co-operative experience with different classmates. Pre-testing with all the instruments took place in October 1994 and the post-testing with mathematics and Slovene language test in June 1995. Pre and post-test were group administered during regular school hours.

Levene's test for equality of variances and *t*-test for equality of means of independent samples were used to analyse the equivalence of CG and EG at the pretest measures. The results showed no statistically significant differences. Two-way analysis of variance (ANOVA) was carried out to assess the comparative effects of the two instructional methods (cooperative (EG) and traditional (CG)) on the two dependent variables separately: students' achievement in mathematics and in Slovene language. The two instructional methods were a between-group factor and the pretest and post-test scores on achievement tests were within-group repeated measure.

The results in EG were further analysed according to students' gender, abilities and cognitive style. Students were grouped into three ability levels according their results on FRT: low ability students (with achievement lower than the first quartile), medium ability students (with achievement between the first and the third quartile), high ability students (with achievement higher than third quartile). The same division

was made for the cognitive style factor (field dependence/independence). Students were grouped into three different groups on the basis of their results on GEFT: field dependent students (with achievement lower than first quartile), students with indistinctive cognitive style (with achievement between the first and the third quartile), and field independent students (with achievement higher than third quartile). A series of analysis of variance was carried out (ANOVA) to assess the effects of gender (male, female), abilities (low, medium, high) and cognitive style (field-dependent, indistinctive, field-independent) on achievement in mathematics and Slovene language. Pre- and post-test results in achievement were within group factors. Gender, abilities and cognitive style were between group factors.

Results

Analysis of variance was carried out to assess the effects of two instructional methods (co-operative versus individualistic) on students' achievements, both in mathematics and in Slovene language. Further series of analysis of variance was carried out to assess effects of student gender, abilities and cognitive style on their achievement in mathematics and Slovene language in cooperative learning treatment (EG). Summarised statistics are shown in tables 1 to 4. *F*-values reflect two-way interactions between treatment groups and time, and two-way interactions between gender, abilities, cognitive style and time in EG.

Cooperative versus individualistic learning and student achievement

Pre-test and post-test in mathematics and Slovene language were standardised (M=0, SD=1) across EG and CG. These standardised scores (z-scores) were used in further analyses.

Relative to the control group those in the cooperative learning group gained more in both courses: in mathematics and in Slovene language.

Table 1: Changes in Mathematics and Slovenian achievement test scores (z) as a function of the cooperative learning treatment (EG).

Test	Time	Control group (CG)	*N*	Experimental group (EG)	*N*	*df*	*MSE*	*F*
1. Maths 1	Pre-	.03		-.01				
2. Maths 2	Post-	-.11		.16				
	Change	-.14	188	.17	164	1,350	4.18	10.72***
3. Slovenian 1	Pre-	.12		-.10				
4. Slovenian 2	Post-	-.15		.17				
	Change	-.27	150	.27	163	1,331	11.57	39.23***

***p<.001

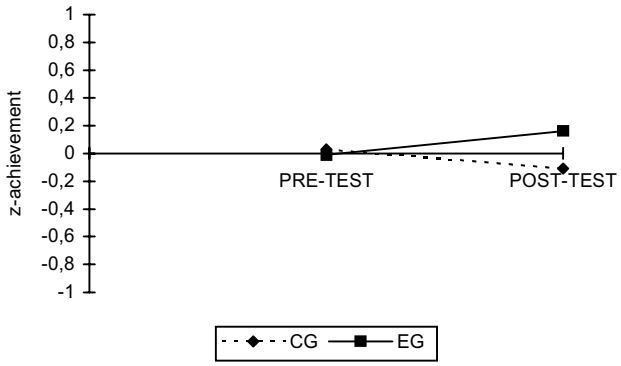

Figure 1: Results in Mathematics achievement test (z scores) for students in EG and CG at pre- and post-test.

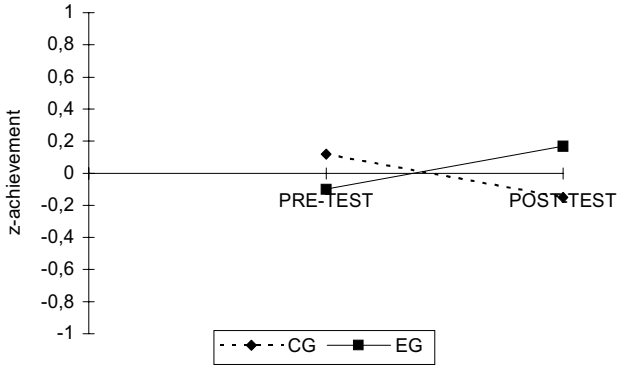

Figure 2: Results in Slovenian achievement test (z scores) for students in EG and CG at pre- and post-test.

Gender and achievement in cooperative learning treatment group

The results showed differences in achievement for boys and girls. The effects were smaller for girls than for boys, consistently so through the two courses. But the results did not reach statistical significance.

Abilities and achievement in cooperative learning treatment group

The results showed differences in achievement for low, medium and high ability students. The largest difference in mathematics was found in low ability students, but no difference was found in high ability students. In Slovene language, the largest difference was also found in low ability students and almost the same differences in me-

Table 2: Changes in Mathematics and Slovenian achievement test scores (z) in cooperative learning treatment (EG) as a function of students' gender.

Test	Time	Male	*N*	Female	*N*	*df*	*MSE*	*F*
1. Maths 1	Pre-	-.12		.09				
2. Maths 2	Post-	.14		.18				
	Change	.26	76	.09	88	1,162	1.46	1.46
3. Slovenian 1	Pre-	-.33		.13				
4. Slovenian 2	Post-	.01		.33				
	Change	.34	75	.20	75	1,148	1.22	1.22

Table 3: Changes in Mathematics and Slovenian achievement test scores (z) in cooperative learning treatment (EG) as a function of students abilities (low, medium, high).

Test	Time	Low abilities	*N*	Medium abilities	*N*	High abilities	*N*	*df*	*MSE*	*F*
1. Maths 1	Pre-	-.69		-.01		.66				
2. Maths 2	Post-	-.30		.17		.65				
	Change	.39	45	.18	73	-.01	46	2,161	0.67	1.73
3. Slovenian 1	Pre-	-.68		-.03		.31				
4. Slovenian 2	Post-	-.29		.18		.56				
	Change	.38	39	.21	67	.25	44	2,147	0.18	.62

dium and high ability students. But analysis of variance revealed that these differences did not reach statistical significance.

Cognitive style and students' achievement in cooperative learning treatment group

Analysis of variance showed statistically significant interactions in mathematics and Slovene language achievement at pre- and post-test in EG according to students'

Table 4: Changes in Mathematics and Slovenian achievement test scores (z) in cooperative learning treatment (EG) as a function of students' cognitive style (field dependent, indistinctive, field independent).

Test	Time	FD	*N*	I	*N*	FI	*N*	*df*	*MSE*	*F*
1. Maths 1	Pre-	-.63		-.01		.65				
2. Maths 2	Post-	-.19		-.01		.84				
	Change	.44	45	.00	76	.19	43	2,161	1.34	3.57*
3. Slovenian 1	Pre-	-.82		-.04		.41				
4. Slovenian 2	Post-	-.26		.11		.66				
	Change	.56	36	.15	73	.25	41	2,147	1.04	3.63*

Cognitive styles: FD – field dependent students; I – students with indistinctive cognitive style; FI – field independent students $^{*}p < 0{,}05$

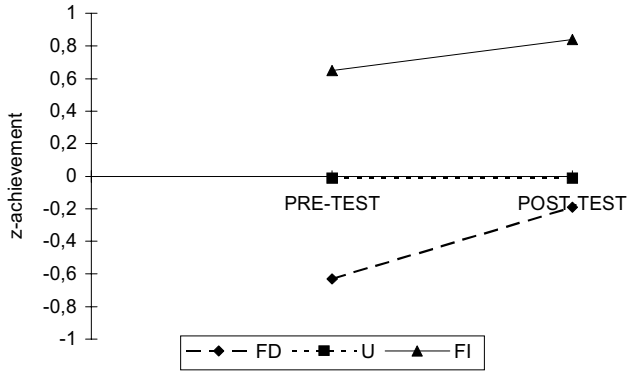

Figure 3: Results in Mathematics achievement test (z scores) for students in EG with different cognitive style at pre- and post-test.

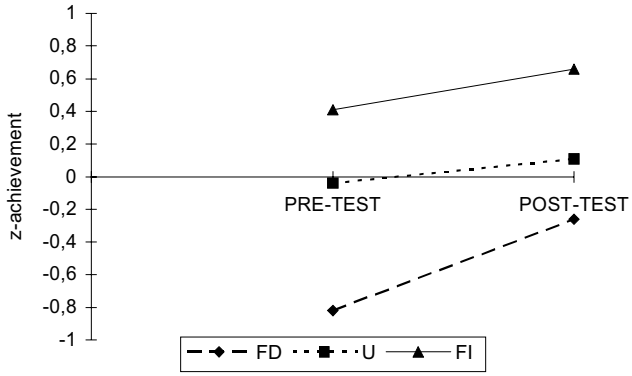

Figure 4: Results in Slovenian achievement test (z scores) for students in EG with different cognitive style at pre- and post-test.

cognitive style. In mathematics achievement the largest change between pre and post-test was in field- dependent students. A positive change was also in field-independent students. No change was found in students with indistinctive cognitive style (Figure 3).

In Slovenian language the largest change in achievement between pre- and post-test was in field-dependent students, and the smallest change in the group of students with indistinctive cognitive style (Figure 4).

Discussion

The first purpose of our study was to investigate the effects of co-operative learning versus traditional learning on students' achievement in mathematics and Slovene lan-

guage. The results of the study showed positive effects of cooperative learning in comparison with traditional (individualistic) learning on students' achievement in both subjects. The results of co-operative learning in our study reflect the adopted approach in introducing cooperative learning in classrooms. In teacher training, we used Kagan's structural approach (Kagan, 1989, Kagan & Kagan, 1994). The key elements of this approach are structures or different ways of interaction organisation in groups that depend on the objectives the teacher would like to achieve. For example: the structure called co-operative cards is appropriate for learning basic facts, group discussion for concept development, group investigation for higher cognitive objective - analysis, synthesis, evaluation. The results of carefully structured interaction in learning and solving problems in co-operative groups can be seen in positive effects in knowledge in both courses: in mathematics and in Slovene language. Achievement tests included basic facts, understanding, application of knowledge and problem solving. These results are consistent with other studies that have revealed positive effects of co-operative learning on achievement across different subjects and different tasks: for verbal and non-verbal, for ill- and well-structured problems (Hall, et al., 1988; Johnson, et al., 1981; O'Donnell et al., 1987; Qin et al., 1995; Sharan & Shaulov, 1990; Slavin 1983).

The second purpose of the study was to find out which students according to their gender, abilities and cognitive style gain most from learning in heterogeneous small groups. Only small and not statistically significant gender differences were detected in our study, which is most probably because the groups were carefully balanced according to members' gender. This result is consistent with other studies that also did not find any effects of gender on students' achievement in cooperative learning, when the number of males and females was balanced in the group (Petersen et. al., 1991; Webb, 1982, 1989).

Abilities are next variable that can also influence group interaction. Although the research revealed that in cooperative learning could gain students with low, medium and high abilities, the results are not consistent (Amaria, Brian, Leith, 1969; O'Donnell & Dansereau, 1992; Cohen, 1994). Webb (1982, 1989, 1992) in her research found that abilities could be related to giving and receiving explanations, and to asking questions and getting an answer in the group. The status of high and low ability students in the group can influence their interaction and some training in helping behaviour can be beneficial to all students with different ability levels (Webb, Farivar, 1994). The results in our study showed that there is no statistically significant interaction between abilities and achievement in cooperative learning treatment. The positive gain for all students could be the result of social skills training as an integral part of co-operative learning in the present study.

Cognitive style field dependence/independence is the only variable influencing the achievement in mathematics and Slovene language in co-operative learning. The highest were gains in field-dependent students, then gains in field-independent students. Achievement of the students with indistinctive style was the same at pre and

post-test. These results can reflect field-dependent students preferences toward learning in social situations. Cooperative learning gave them the social frame where they could get peer help and answers to their questions. Field-independent students can also benefit from group learning with their systematic and strategic approach toward problem solving and learning tasks (c.f. Druyan & Levin, 1995).

Some implications for educational practice can be drawn from the research. Kagan's structural approach toward cooperative learning was approved as more successful than traditional individualistic approach. This approach combines very carefully structured interaction with teaching social skills that are necessary for learning in groups. With this structure the effects can be beneficial for girls and boys, for students with different abilities and for field-dependent and field-independent students. These research findings are very important argument when professionals talk to teachers and parents and explain them the goals and benefits of cooperative learning. They are the answer to their frequently asked question, namely:" why would my child (student) work with others and help them, if he or she could learn more alone?" Properly structured cooperative learning can be beneficial to all students, regardless of their level of ability, gender or cognitive style.

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