Influence of cooperative problem solving on students' control and help-seeking strategies during mathematical problem solving

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Abstract

Developing problem solving is one of the main goals of school education. A self-regulated learner have more success in problem solving, as developing self-regulated learning skills should be an important goal of school education. A teacher, in order to be able to develop their pupils' self-regulated learning skills, should master these skills. Thus developing these skills should be an essential goal of teacher education. In this paper two important skills of a self-regulated learner are studied: control and help-seeking behavior during problem solving. The article presents a research on the influence of the cooperative problem solving strategies on students' self-control and self-monitoring during problem solving, and their help seeking strategies in case of unsuccessful problem solving. The results show that students' control decrease when using cooperative problem solving; cooperative problem solving helped students to realize the importance of asking for help when solving problems; and cooperative problem solving prevent increasing the giving up rate in case of non-routine problems.

Keywords

Cooperative problem solving, mathematical problem solving, help-seeking strategies, control during problem solving

Résumé

L'un des principaux objectifs de l'éducation scolaire est le développement des

compétences de la résolution de problèmes. Un apprenant autorégulé a plus de succès dans la résolution de problèmes; en conséquence le développement des habiletés d'apprentissage auto-régulé des étudiants devrait être un objectif important de l'enseignement scolaire. Afin d'être en mesure de développer les compétences d'apprentissage auto-régulé à ses étudiants l'enseignant doivent les maîtriser lui-même et leur développement devrait être un objectif essentiel de la formation des enseignants. Dans cet article sont étudiés deux compétences importantes d'un apprenant autorégulé: le contrôle et le comportement de recherche d'aide aux cours de la résolution de problèmes. L'article présente une recherche sur l'influence des stratégies de la résolution coopérative de problèmes sur le comportement d'auto-contrôle des étudiants et sur les stratégies utilisées à la recherche d'aide en cas d'échec dans la résolution de problèmes. Les résultats mettent en évidence la diminution de contrôle des élèves lors de la résolution des problèmes par coopération. De plus, la résolution coopérative des problèmes aidé les élèves à comprendre l'importance de demander de l'aide pour résoudre des problèmes; la résolution coopérative des problèmes prévenue l'augmentation du nombre des situations d'abandon des tâches en cas de problèmes non routinières.

Mots-Clés

La résolution coopérative des problèmes, la résolution des problèmes mathématiques, les stratégies de la recherche d'aide et de contrôle aux cours de la résolution de problèmes

Introduction

Developing problem solving is one of the main goals of school education. Self-regulated learning skills are important for a successful problem solving (Schwartz et al., 1998). Self-regulation refers to those processes which monitor and control performance, cognition, and affects (Efklides, Niemivirta & Yamauchi, 2002). Even students with low-achievement who have self-regulated learning skills are able to solve problems as well as their colleagues with higher achievement (Howard, McGee, Shia & Hong, 2001). Mathematics teachers expect their students to assume control during their problem solving process (De Corte, Verschaffel & Op't Eynde, 2000). In this paper two important skills of a self-regulated learner are studied: self-control and help-seeking behaviour.

Control is present in each stage of the problem solving, for example, selecting the relevant information in the problem analysis stage; checking if all the data is used in the problem solving stage; checking if the solution is correct or if the problem could be solved by other methods too in the reflection stage. It is important that pre-service teachers develop self-control during problem solving, and they know how to develop these skills in their pupils.

Help-seeking should be considered integral part of a mathematics classroom (Gravemeijer, 2004) as it contributes to a successful coping with the learning task (Karabenick, 2004). Help-seeking behaviour it could be influenced by the teachers, as there is a lack of this behaviour in classes where the teacher often makes students to feel ashamed when they don't understand something (Turner et al., 2002) or in classes where the teacher thinks that help-seeking make more difficult the development of individual problem solving skills (Marchand & Skinner, 2007). Thus it is important that pre-service teachers develop a positive attitude towards help-seeking and they master different help-seeking strategies.

The article presents a research on the influence of the cooperative problem solving strategies on students' self- control and self-monitoring during problem solving, and their help seeking strategies in case of a blockage.

Theoretical Background

A problem is "a situation that requires a solution and/or decision, no matter whether the solution is readily available or not to the solvers" (Fan & Zhu, 2007, p. 64). Problems could be routine and non-routine problems. Routine problems are those problems, which can be solved by applying a known algorithm (Pólya, 1957; Holmes, 1995). Non-routine problems are problems, which are unfamiliar to students; "they make cognitive demands over and above those needed for solution of routine problems, even when the knowledge and skills required for their solution have been learned" (Mullis et al., 2009, p. 45).

In order to solve non-routine problems someone needs to master a certain level of problem solving competency. This competency is "an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricula areas that might be applicable are not within a single domain of mathematics, science or reading" (OECD, 2003, p. 156).

Self-regulated learning skills help students to solve non-routine problems successfully (Schwartz et al., 1998). Self-regulated learners are metacognitively, motivationally and behaviorally active participants in their own learning process (Zimmerman, 1986). Self-control and self-monitoring of the cognitive strategies, motivation, and behavior are important self-regulated learning skills for problem solving. Rheinberg, Vollmeyer and Rollett (2000) identified the following four control strategies: attention, motivation, emotion, and decision control. Attention control is essential, as in many cases even high achieving students make mistakes in their tasks due to lack of attention. Related with mathematical problem solving "control has to do with the decisions and actions undertaken in analysing and exploring problem conditions, planning courses of action,

selecting and organizing strategies, monitoring actions and progress, checking outcomes and results, evaluating plans and strategies, revising and abandoning unproductive plans and strategies, and reflecting upon all decisions made and actions taken during the course of working on a problem" (Lester, Garofalo & Kroll, 1989, p. 4).

When solving non-routine problems, some stages should be followed: understanding the problem, devising a solving plan, carrying out the plan, looking back (Pólya, 1957). Self-control should be present in every stage of the problem solving, for example checking if all the data are used during the planning and carrying out the plan stage; checking if the solution is correct or if the problem can be solved by another method during the looking-back stage, etc.

Help seeking strategies are also important for a successful problem solver. Help seeking is "*an achievement behavior involving the search for and employment of a strategy to obtain success*" (Ames & Lau, 1982, p. 414). There are two types of help-seeking: instrumental and executive (Karabenick, 2004). During executive help-seeking the student try to reduce the invested time and effort, i.e. to find the result of a problem without solving it, so the main goal is to complete the task. During instrumental help-seeking the student try to get the minimal help for overtaking blockage during problem solving, i.e. to get a hint in order to continue individual problem solving, so the main goal is to learn. Help-seeking has the following steps: recognizing the need of help, deciding to ask for help, identifying possibilities of getting help, and using adequate strategies for getting help (Ryan, Pintrich & Midgley, 2001). While learning Mathematics, in case of an unsuccessful problem solving pupils need to be able to find different ways of overtaking the blockage, as searching for similar worked examples in their copybooks or textbooks, searching for books in library or on the internet which could help, asking for the help of their peers or their teacher, etc.

In cooperative learning students work in mixed groups together to achieve common goals, and for this they have to discuss with each other, they have to help each other (Johnson & Johnson, 1999; Doymuş, Şimşek & Bayrakçeken, 2004). Collaborative problem solving is "the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and effort to reach that solution" (OECD, 2013). Based on the literature in cooperated working/learning, it is recommended that groups remain together for a longer time, e.g. for the whole duration of a project or for half of a semester, in order to know each other's strengths and weaknesses, and to experiment how to communicate and work together, and how to support each other (Millis, 2002). Also, the learning is more efficient if the cooperative groups are heterogeneous as regarding pupils' achievements and gender (Mueller & Fleming, 2001; Toumasis, 2004).

Research design

This research was carried out in the first semester of the 2013/2014 university year at Babes-Bolyai University, Cluj-Napoca in Romania.

Research goal

The aim of this research is to study the influence of cooperative problem solving in developing self-control and help-seeking behaviour.

Research sample

The sample is made from two groups of Preschool and Primary School Pedagogy specialization students from Babes-Bolyai University: the control group with 24 second year students and the experimental group with 21 third year students, in total 45 students. These two groups had their first university level Mathematics course in the same semester due to curricula change. 43 students are female and 2 male, this reflects the gender distribution among pre-service and in-service primary school teachers.

Research tool

The research tool was a questionnaire with 28 items: 3 demographical items asking students' year of study, gender, and age; and 25 items related with self-regulated learning of Mathematics, items measured on a 4 point Likert scale: 1 – don't agree, 2 – a bit agree, 3 – agree, 4 – totally agree. Cronbach's alpha reliability of the questionnaire is 0.79.
Students from the experimental and control group were twice tested with this questionnaire: at the beginning and at the end of the semester.

Intervention

During the semester both groups were taught by the researcher. A problem solving approach was adopted for learning Mathematics. The researcher emphasized on non-routine problems in order to develop students' problem solving competence. The same problems were solved in both groups.

In the control group individual and frontal work was used: students got the problem sheet and got time for individual thinking and problem solving, then the solution was discussed frontally on the blackboard.

In the experimental group cooperative problem solving techniques were used. In Table 1 we see a short description of each technique and some remarks of the special advantage of some of the techniques. Pairs or groups of 3 or 4 students were randomly chosen during each lesson using different random group forming methods. Even if the scientific literature recommend permanent heterogeneous groups, we couldn't apply this recommendation, as the presence on the classes is not mandatory, so not each student is present during each lesson. The advantage of the changing groups is that during the

semester practically each student met almost all the other students in a cooperative problem solving situation, and for a future primary school teacher is important to explain mathematics for more persons with different mathematical competences.

Table 1

Cooperative problem solving techniques used during the intervention

Technique	Pair/ group	Description	Advantages
Think-pair-share	Pair	Each student gets the same problem, and they solve it individually. Then they discuss the solution in pairs, they improve their solution if it is necessary (Felder & Brent, 2009).	
Learning a problem solving strategy	Group	Each group gets a problem sheet with problems which can be solved by the same strategy. Each student gets a problem from this problem sheet which he/she solves individually. Then each student presents his/her problem and solution. If a student can't solve his/her problem, then he/she will try to solve it again individually after the presentations of the team-members. Their team-mates can help only if he/she can't solve it even after the presentations.	For the student who can't solve his/her problem this method offers several worked examples which can be solved by the same strategy as his/her problem.
Cascade	Group	Each team gets a problem sheet with problems built on each other. Each student gets a problem from this problem sheet. The first student solves the first problem, then pass it to the second student. The second student checks the solution of the first problem and he/she solves the second problem, etc. The last student gives back the problem sheet to the first student, who checks the solution of the last problem (Zsoldos-Marchis, 2015).	The responsibility of each group member is higher as each solution contribute to the solution of the problem which has to be solved by the group.
Contribute to a problem	Group	Each team gets a problem sheet with problems, which could be related by the topic, but they can be solved separately. Each student gets a problem from this problem sheet which he/she solves individually. Then the team gets a problem, which requires data from the problems solved individually by the team members. Before they solve this problem, they check all the problems solved by the team members (Zsoldos-Marchis, 2015).	
Thinking-aloud pair problem solving	Pair	One pair member is the explainer and the other one is the questioner. The explainers explain the problem and the solution, the questioner ask questions any time the explanation is not clear or not complete. For the next problem the roles are changed. (adaptation from Felder & Brent, 2009).	Students need to explain to their colleagues their solution, an essential skill for a future teacher.
Jigsaw technique	Group	Students work in groups. Each home group gets the same problem sheet, to each student is assigned one specific problem from this problem sheet. Each student solves the problem, then the students having the same problem form a group and discuss their solutions in this group. Each student returns to his/her group, where he/she will be the expert of his/her problem. Everybody from the group solves the whole problem sheet. The expert helps, if it is necessary, and verifies the team-members' solutions [adaptation for problem solving from Şengül & Katranci, 2014; technique first described in (Aronson et al., 1978)].	

Technique	Pair/ group	Description	Advantages
Send a problem	Group	Each group composes a problem and writes the text of the problem on a card; then they pass the problem to another group. Each group solves the problem they get; then they pass the solution back to the group who composed the problem, they evaluate the solution. (adaptation from Kagan, 1989).	Students need to compose problems, a useful skill for a pre-service teacher.
Compose a problem based on a partial solution	Pair	Each pair composes a problem which they solve it. They write the solution on an A4 paper, then cut a piece of this paper (for example they can cut the paper in two vertically, or they can cut a horizontal band, etc.). They pass this piece to another pair, who try to guess what the problem about and compose a problem with the data identified in the paper piece. Then they solve this problem. Then each pair first meet the pair from who they got the problem, then they meet the pair to whom they sent the piece of the solution. Together compare the two problems (Zsoldos-Marchis, 2015).	
Find more solving strategies	Pair	Each pair gets a problem which they solve it, then pass the problem and the solution to another pair. They check the given solution, solve the problem using another strategy, and pass the problem and the two solution to another pair. They check the two solutions, solve the problem using another strategy, and pass the three solutions to the initial pair, who check them. (Zsoldos-Marchis, 2015).	Students are forced to think to solve a problem using more problem solving strategies. A teacher have to be aware that a problem could be solved with more strategies and he/ she should be able to solve the same problem using more strategies.

Results And Discussion

We selected 8 items and we have grouped the selected items in two clusters: items related with control during problem solving and items related with the help-seeking behaviour in case of unsuccessful problem solving.

Students' control behaviour during problem solving

Table 2, 3, and 4 presents the data related with students' control during problem solving. In Table 2 and 3 we can observe the percentages of those students selecting variants "don't agree", "a bit agree", "agree", and "strongly agree" on the pre-test and post-test in case of the experimental respective control group. In order to get the percentages of those students who are characterized by the given affirmation, we added the variants "agree" and "strongly agree". Table 4 contains the averages, standard deviations in case of each affirmation for each groups at the pre-test and post-test, and the t-test results.

TABLE 2

Control during problem solving – experimental group's results

Affirmation	Pre-test					Post-test				
	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)
During problem solving I check if I used all the given data	0	4.76	61.90	33.33	95.23	4.76	14.29	42.86	38.10	80.96
After I solve a problem, I check, if the solution is correct	0	14.29	57.14	28.57	85.71	4.76	23.81	28.57	42.86	71.43
After I solve a problem, I think about other possible methods for solving it	23.81	38.10	33.33	4.76	38.09	19.05	47.62	33.33	0	33.33

Observing the pre-test results, we can see that a high percentage of the students (95.23% in experimental group (Table 2) and 83.34% in control group (Table 3) check if they used all the data of the problem. This percentages are higher than in case of in-service primary school teachers, only 77.40% of them check if they used all the data (Marchis, 2011). A high percentage of the students from the experimental group (85.71%) check if the solution is correct (Table 2); but only half (54.16%) of the students from the control group checks the correctness of the solution (Table 3). Comparing with data for in-service primary school teachers, 64.5% verify the correctness of the solution (Marchis, 2011), this is a smaller percentage than in case of the experimental group. About third of the students (38.09%) of the experimental group and fifth of the students (20.84%) of the control group think about more methods of solving a problem. This percentages are higher than in case of in-service primary school teachers, as only 12.9% of them think about more ways of solving a problem (Marchis, 2011). A teacher

TABLE 3

Control during problem solving – control group's results

Affirmation	Pre-test					Post-test				
	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)
During problem solving I check if I used all the given data	0	16.67	54.17	29.17	83.34	4.17	12.50	50.00	33.33	83.33
After I solve a problem, I check, if the solution is correct	8.33	37.50	33.33	20.83	54.16	4.17	41.67	25.00	29.16	54.16
After I solve a problem, I think about other possible methods for solving it	45.83	33.33	16.67	4.17	20.84	45.83	37.50	12.50	4.17	16.67

needs to be aware that a problem could be solved correctly by more methods, and she/he needs to know more problem solving strategies for the same problem. This is important as pupils could come with different ideas when discussing the solution of a problem in the classroom, and the teacher should be able to check, if those ideas or solutions are correct.

In the experimental group in case of all three affirmation the percentage of those students who are characterized by the given behaviour decreased. The averages in case of these affirmations are also decreased (Table 4). As regarding control group, in case of the first two affirmations (checking, if they used all the data and if the solution is correct) the percentage of those students who are characterized by that behaviour are constant (Table 3). In case of the third affirmation (thinking about other possible methods for solving the problem) there is a decrease of the percentage of those students who are characterized by that behaviour. Looking on the averages (Table 4), there is a stagnation in case of the first affirmation, there is an increase in case of the second, and a decrease in case of the third.

Table 4

Control during problem solving – comparing pre-test and post-test results for the two groups

Affirmations	Tests	Groups	N	Mean	St. dev.	p	t
During problem solving I check if I used all the given data	Pre-test	Control	21	3.13	0.46	0.20	-0.66
		Experimental	24	3.29	0.31		
	Post-test	Control	20	3.13	0.63	0.47	-0.07
		Experimental	20	3.14	0.73		
	Pre-test	Experimental	20	3.29	0.31	0.22	0.77
	Post-test		20	3.14	0.73		
After I solve a problem, I check, if the solution is correct	Pre-test	Control	21	2.67	0.84	0.27	-1.98
		Experimental	24	3.14	0.43		
	Post-test	Control	20	2.79	0.87	0.14	-1.08
		Experimental	20	3.10	0.89		
	Pre-test	Experimental	20	3.14	0.43	0.42	0.21
	Post-test		20	3.10	0.90		
After I solve a problem, I think about other possible methods for solving it	Pre-test	Control	21	1.79	0.78	0.06	-1.52
		Experimental	24	2.19	0.76		
	Post-test	Control	20	1.75	0.72	0.05	-1.65
		Experimental	20	2.14	0.52		
	Pre-test	Experimental	20	2.19	0.76	0.42	0.21
	Post-test		20	2.14	0.52		

Students' help-seeking behaviour in case of unsuccessful problem solving

Table 5, 6, and 7 presents the data related with students' help-seeking behaviour in case of unsuccessful problem solving. In Table 5 and 6 we can observe the percentages of those students selecting variants "don't agree", "a bit agree", "agree", and "strongly agree" on the pre-test and post-test in case of the experimental respective control group. In order to get the percentages of those students who are characterized by the given affirmation, we added the variants "agree" and "strongly agree". Table 7 contains the averages, standard deviations in case of each affirmation for each groups at the pre-test and post-test, and the t-test results.

According to the pre-test results, when they can't solve a problem, 100.00% of the students from the experimental group read the text of the problem again, 85.71% search for similar worked examples, 71.43% ask for help (Table 5). In case of the control group the order is different, 83.34% read again the problem, 79.17% ask for help, and 54.16% search for similar worked examples (Table 6). Comparing these results with those for in-service primary school teachers', pre-service teachers from this research have a better help-seeking behaviour, as in case of in-service teachers the percentages are lower for each affirmation: 67.70% read the text again, 41.9% search for similar worked

TABLE 5

Students' help-seeking strategies in case of an unsuccessful problem solving – experimental groups' results

Affirmation If I can't solve a problem …	Pre-test					Post-test				
	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)
I read again the text of it	0	0	42.86	57.14	100.00	0	9.52	28.57	61.10	89.67
I search for a similar worked example	0	14.29	61.90	23.81	85.71	4.76	0	57.14	38.10	95.24
I ask for help	4.76	23.81	47.62	23.81	71.43	0	28.57	33.33	38.10	71.43

examples, and 35.50% ask for help from a colleague (Marchis, 2011). In case of the experimental group the order of the percentages choosing the different affirmations have changed on the post-test, 95.24% search for a similar worked example, 89.67% read the problem again, 71.43% ask for help. The percentage of those trying to overtake the blockage by rereading the problem decreased, and the percentage of those trying to find similar worked examples increased. The percentage of those students who ask for help didn't change, but increased the percentage of those choosing variant "strongly agree" from 23.81% to 38.10%. In the case of the control group the changes in percentages are not so relevant, in case of each affirmation the percentage slightly increased. But observing the percentage of those choosing variant "strongly agree", this increased from 20.83% to 33.33% in case of affirmation "I search for a similar worked example." and decreased from 37.50% to 29.17% in case of affirmation "I ask for help".

Also, observing the averages, we see that in case of affirmation "I ask for help" the mean for experimental group increased from 2.90 to 3.10, and the mean from control group decreased from 3.17 to 3.08. This shows that cooperative problem solving make students to realize that asking help is not a negative learning behaviour and helping each other in the group increase learning results.

TABLE 6

Students' help-seeking strategies in case of an unsuccessful problem solving – control groups' results

Affirmation If I can't solve a problem …	Pre-test					Post-test				
	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)
I read again the text of it	0	16.67	29.17	54.17	83.34	4.17	8.33	45.83	41.67	87.50
I search for a similar worked example	16.67	29.17	33.33	20.83	54.16	4.17	37.50	25.00	33.33	58.33
I ask for help	0	20.83	41.67	37.50	79.17	4.17	12.50	54.17	29.17	83.34

Students' emotional response in case of unsuccessful problem solving

Table 8, 9, and 10 presents the data related with students' emotional response in case of unsuccessful problem solving. In Table 8 and 9 we can observe the percentages of those students selecting variants "don't agree", "a bit agree", "agree", and "strongly agree" on the pre-test and post-test in case of the experimental respective control group. In order to get the percentages of those students who are characterized by the given affirmation, we added the variants "agree" and "strongly agree". Table 10 contains the averages, standard deviations in case of each affirmation for each groups at the pre-test and post-test, and the t-test results.

So, regarding negative response to unsuccessful problem solving, based on the pre-test results, 19.05% of the experimental group and 20.83% of the control group give up quickly, 19.04% of the experimental group and 29.16% of the control group feel a negative attitude towards Mathematics if they can't solve a problem. In the experimental group the percentage of those giving up quickly doesn't change on the post-test, but increased from 19.04% to 33.34% in the control group. The difference on the post-test is statistically significant [$t(43) = 1.89$ and $p = 0.03$, Table 7]. In case of the other affirmation, in both groups the percentage of those developing negative attitude towards Mathematics in case of unsuccessful problem solving has increased.

TABLE 7

Students' help-seeking strategies in case of an unsuccessful problem solving – comparing pre-test and post-test results for the two groups

Affirmations If I can't solve a problem …	Tests	Groups	N	Mean	St. dev.	p	t
I read again the text of it	Pre-test	Control	21	3.38	0.59	0.16	-0.99
		Experimental	24	3.57	0.26		
	Post-test	Control	20	3.25	0.63	0.11	-1.23
		Experimental	20	3.52	0.46		
	Pre-test	Experimental	20	3.57	0.26	0.36	0.37
	Post-test		20	3.52	0.46		
I search for a similar worked example	Pre-test	Control	21	2.58	1.04	0.03	-1.99
		Experimental	24	3.09	0.39		
	Post-test	Control	20	2.88	0.90	0.06	-1.62
		Experimental	20	3.29	0.51		
	Pre-test	Experimental	20	3.09	0.39	0.19	-0.89
	Post-test		20	3.29	0.51		
I ask for help	Pre-test	Control	21	3.17	0.58	0.14	1.10
		Experimental	24	2.90	0.69		
	Post-test	Control	20	3.08	0.60	0.48	-0.05
		Experimental	20	3.10	0.69		
	Pre-test	Experimental	20	2.90	0.69	0.16	-1.00
	Post-test		20	3.10	0.69		

CONCLUSION, LIMITATIONS, FUTURE DIRECTIONS

In this research we investigated the influence of cooperative problem solving on students' control and help-seeking behaviour during problem solving. The results show that students' control decrease when using cooperative problem solving. This could be explained by the fact that during cooperative problem solving students get feedback from their teammates, as during each cooperative problem solving strategy there is at

Table 8

Students' emotional response in case of an unsuccessful problem solving – experimental groups' results

Affirmation If I can't solve a problem ...	Pre-test					Post-test				
	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)
I give up quickly	38.10	42.86	14.29	4.76	19.05	38.10	42.86	14.29	4.76	19.05
I feel a negative attitude towards Mathematics	38.10	42.86	9.52	9.52	19.04	33.33	38.10	4.76	23.81	28.53

least one step of verifying each other's work, so students don't feel necessary a strong individual control. This influence of cooperative problem solving on students' control is not a desirable one. If this influence is confirmed by other experiments too, then some individual work steps should be included in the cooperative problem solving techniques in order to constrain students for self-control.

Cooperative problem solving made students to realize the importance of asking for help when getting stuck during problem solving. Probably, during cooperative work they also learnt how to get and offer help in constructive way (instrumental help-seeking).

Even if during the course non-routine problems were promoted by the researcher, in the experimental group the percentage of those giving up quickly if they can't solve a problem didn't change, as in the control group increased, being a statistically significant difference between the two groups on the post-test.

This research has an important limitation: it was carried out during a university course on which the constant presence is not mandatory. Usually students with positive attitude towards learning Mathematics or better problem solving skills have a better presence on the courses than students with a less positive attitude or poorer problem solving skills. This second category is that one which could really benefit from using one teaching method or other, in this case using cooperative problem solving techniques. Another limitation is related with the duration of the intervention. This course was only

TABLE 9

Students' emotional response in case of an unsuccessful problem solving – control groups' results

Affirmation If I can't solve a problem …	Pre-test					Post-test				
	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)	Don't agree (%)	A bit agree (%)	Agree (%)	Strongly agree (%)	Students who are characterized by the given behaviour (%)
I give up quickly	16.67	62.50	20.83	0	20.83	8.33	58.33	29.17	4.17	33.34
I feel a negative attitude towards Mathematics	16.67	54.17	20.83	8.33	29.16	16.67	41.67	29.17	12.50	41.67

TABLE 10

Students' emotional response in case of an unsuccessful problem solving – comparing pre-test and post-test results for the two groups

Affirmations	Tests	Groups	N	Mean	St. dev.	p	t
If I can't solve a problem I give up quickly	Pre-test	Control	21	2.04	0.39	0.20	0.83
		Experimental	24	1.86	0.73		
	Post-test	Control	20	2.29	0.48	0.03	1.89
		Experimental	20	1.86	0.73		
	Pre-test	Experimental	20	1.86	0.73	0.50	0.00
	Post-test		20	1.86	0.73		
If I can't solve a problem I feel a negative attitude towards Mathematics	Pre-test	Control	21	2.20	0.69	0.13	1.15
		Experimental	24	2.19	0.76		
	Post-test	Control	20	2.38	0.85	0.27	0.59
		Experimental	20	2.19	1.36		
	Pre-test	Experimental	20	1.90	0.89	0.09	-1.37
	Post-test		20	2.19	1.36		

one semester long (14 weeks), and developing a positive attitude towards mathematics and problem solving needs more time. Would be interesting to repeat this research with a longer intervention lasting at least two semesters. Unfortunately the students involved in this research have only one Mathematics course lasting one semester during their studies. Another aspect to be considered is that students filled in the questionnaires giving their names, this was necessary for comparing pre-test and post-test results. Could happened, that some of the students' responses was influenced by the fact that they have to give their names when filling in the questionnaires.

This research could have been completed by interviews with students in order to see what factors contributed to the changes presented in this paper.

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