

Cooperative Learning and Peer Tutoring to Promote Students' Mathematics Education

Angela Pesci

Associate Professor, Department of Mathematics, University of Pavia, Italy
angela.pesci@unipv.it

Abstract

On the basis of experiences and studies developed in the last ten years, the contribution aims to discuss some different peculiarities between Cooperative Learning and Peer Tutoring models in Mathematics lesson. These models are specific interpretations of a way of conducting Mathematics lessons which requires the activity of students, their personal participation in the construction of knowledge. In the description of the two teaching-learning models, the analysis will deal in particular with the social aspects these models involve. Describing these two modalities of cooperation, also the importance of the care for the choice of suitable mathematical tasks and for different pedagogical setting they require will appear clearly. The issues described, together with the analogies and differences between the two models, could contribute to suggest more adequate didactical projects for teachers and deeper studies about students' collaboration based models for researchers.

The Cooperative Learning Model

Starting from the conviction that it is necessary to redefine the didactic system (teacher – student – knowledge – environment, Brousseau, 1997) in the terms of a more global interpretation of the personal relationships which intertwine in it (Pesci, 2002), I studied and put in practice with a group of teachers the model of “cooperative learning”. It is well known that it is an educational strategy based on social mediation: the resources for the construction of knowledge are the students, who are called upon both to accomplish a disciplinary task and to develop social abilities and the role of the teacher remains fundamental, being the organizer and facilitator of the entire process. In the quoted work I described an historical itinerary of the development of this teaching-learning model in the last 30 years, detailing the general principals which the model is based on: in synthesis, *positive interdependence*, which is reached when the members of the group understand that collaboration is necessary and that individual success cannot exist without collective success; furthermore, it is fundamental the definition and *assignment of roles* to each component of the cooperative group. The division of social and disciplinary skills amongst the members of the group encourages collaboration and interdependence, assures that individual abilities are utilized for the common work and reduces the possibility that someone refuses to cooperate or tends to dominate the others.

Another essential component regards *social abilities*: an efficient management of interpersonal relationships requires that the students know how to sustain a leadership role within the group, take decisions, express themselves and listen, ask and give information, stimulate discussions, know how to mediate and to share, know how to encourage and to help, facilitate communication, create a climate of trust and resolve possible conflicts. These abilities must be taught with the same awareness and care with which disciplinary abilities are taught.

Without entering in other details (for more pragmatic aspects I remind to Pesci, 2002, 2004), I believe important for the aims of this contribution to see the five *roles* in each cooperative group, according to the translation of this model done in the practice of our experiences.

the orientated to the task: this is the student who must make sure that his group reaches the best result in relation to the mathematical task assigned. He has to translate the task into an appropriate work plan, making sure that no-one is lost in secondary aspects of the problem, making the point of the situation and urging the group to take decisions;

the orientated to the group: this is the student who is responsible for the communicative climate. He must, therefore, make sure that everyone participates positively in the solution of the task, encouraging anyone who seems to be in difficulty, making sure that the interventions are balanced in times and ways and playing down any possible conflicts;

the memory: he is responsible for the verbalization of the results of the group. During the work, he repeats the shared decisions, asks for the confirmation of partial formulations of the

results and of the final report, agreeing with all of the components of the group, but overall with *the speaker*;

the speaker: he is the manager, for the group, of the oral report on the results of the collaborative work carried out. He arranges, with *the memory*, the final version of the results reached and reads them to the entire class in the final presentation phase;

the observer: he is responsible for the observation of the interactive process of the group. He observes whether or not each one carries out the task actively and appropriately, for example without predominating, whether or not each one suitably performs correctly his role. He takes notes on what he has observed and communicates them to the entire class in the final discussion phase.

It is essential that there is the rotation of these *roles* for the students: each one must have the possibility to live every *role*, making experience of different duties to accomplish: only in this way all his/her resources could emerge and develop.

The role foreseen for the teacher is that of *supervisor*. Beyond the organization of the work outside of the class (choice of the disciplinary task, choice of the criteria for the formation of the group, preparation of the didactic material), in class, during the cooperative work, he must not give suggestions relative to the solution of the task assigned but be particularly attentive to the interrelational processes.

At the end of the group work there is a class discussion in which all the results obtained are shared, as well as any possible unresolved problems. This final phase foresees the presentation of the *speakers* and then the presentation of the *observers*. At this point the discussion is opened up to the whole class and the teacher is responsible for a fruitful debate, both on the results of the disciplinary task assigned and on possible problems emerged during the assumption of the roles. It is, therefore, evident that opportunities for reflection, both on the discipline and on the interpersonal relationships, are continuously offered to the class.

At the conclusion of all the work, it is important that the students are invited to express their *evaluation* of the work done, for example, on a form prepared by the teacher, structured with precise questions or open for freer observations by the students.

In relation to the cooperative experiences already carried out and analyzed it must be stressed that positive results have been reached both on a disciplinary and on a relational level (Baldrihi et al., 2003, 2004, 2007). The most significant attitudes and behaviors observed by teachers have been the following.

On the disciplinary level, the pupils learn to collaborate in order to get a good result, thus reducing the anxiety often connected to individual tasks and facilitating the learning process; they get more easily involved in the development of concepts and show that they feel protagonists and active players in the discoveries and elaborations carried out; they become aware that collaboration is much more rewarding than competition and gives better results; they show greater motivation in learning and they put more trust in their own possibilities (this is particularly true for students of an intermediate/low level), spontaneously expressing their ideas and thus voluntarily bringing themselves into play.

The positive value of cooperative experiences refers also to interpersonal relationships: students more easily develop or consolidate friendship; they realize that it is not necessary to be “the best” of the class in order to be accepted into it and give useful contributions for all; they show a better willingness in following the teacher's didactical project.

The Peer Tutoring Model

After some years of practice based on the *Cooperative Learning* model, we developed also experiences in secondary school through *Peer Tutoring*, aiming at both the disciplinary support for pupils in difficulties and the involvement of students (whether or not in difficulties) in the same project (Torresani, 2008). Assuming that usual support classes do not always give satisfying results and are quite disappointing for teachers too (Torresani, 2008, Cusi, 2007), it seemed a better choice to organize activities involving the entire class with the aim of recovering disciplinary abilities of students in difficulties and at the same time of strengthening those of the others.

After a suitable preparation of the class, the teacher usually proceeds to the organization of couples or groups of three formed by students with significant differences in terms of school

results and where it seems most likely for interpersonal relationships to be consolidated or created from the beginning. The teacher then arranges with the class a schedule for the project which organizes the timing of the subjects. The teacher must also arrange the necessary material (papers with activities of gradual difficulty taken from books or elaborated for the purpose). During the tutoring activity the teacher must always be available as an expert to resolve possible doubts to *tutors* and as supervisor of the activity.

The student involved in the role of *tutor* must use many cognitive abilities: he will have to give suggestions and provide explanations, manage the material and select the subjects which his student has to reinforce through exercises, check and report the results. Among the requisites necessary for the success of the tutoring process we must not forget the social abilities essential for the creation of a good relationship putting the pupil at ease and allowing the sharing of the proposed objectives.

The systematic monitoring of the results carried out by the *tutors* is often helped by a form which has to be filled-in by the student. This form is provided at each meeting and suggests a reflection on the difficulties and the particular abilities of the pupil.

The *pupil* will have to keep a copybook dedicated to this experience, which will relate both the activities carried out in class and the homework assigned by the *tutor*.

Tutoring experiences on a chosen specific disciplinary subject are usually kept in two or three meetings with a final classwork. While the *pupil* is developing his disciplinary task, the *tutor* elaborates a tutoring report and, in some cases, he also carries out a part of the task. This report is a significant tool not only in relation to the activity of disciplinary recovery but also for the metacognitive reflection on one's own work: in fact, in elaborating this report, the *tutor* pupil is called to give previsions referring to the possible results of his tutored *pupil* (also considering the will for work showed by the pupil) through questions like the following:

1. Among the subjects discussed (*here follows a list of the subjects*) mark with a + the subject you think your pupil is most prepared on and with a - that on which you think your pupil is still in difficulties.
2. How would you evaluate the work of your pupil in carrying out the activities developed in class?

Scarce	Discontinuous	Diligent	Constant	Remarkable
--------	---------------	----------	----------	------------
3. How would you evaluate the work of your pupil in carrying out the homework?

Scarce	Discontinuous	Diligent	Constant	Remarkable
--------	---------------	----------	----------	------------
4. Did you have any trouble in your relationship with your pupil? If so, what kind of trouble?
5. What did you find to be the most difficult thing in teaching?
 - a) Give explanations about processes
 - b) Manage the material
 - c) Understand your pupil's difficulties
 - d) Manage the relationship with the pupil (be patient, gain his trust,...)
 - e) Other
6. When the communication with the pupil was successful, this was because:
 - a) You used simpler words than those on the book or those used by the teacher
 - b) Between classmates there is no fear in expressing perplexities and reservations
 - c) You understood what your pupil was most skilled in and, starting from there, you succeeded in making him progress
 - d)

With reference to the question n. 5, the great majority of the *tutor* pupils chooses the following aspects: give explanations about processes and understand the pupil's difficulties. These aspects are taken by many *tutors* as challenging tasks as they greatly enhance the pride for their personal abilities. If we consider the teachers' observations and the students' final reports, we can see that the awareness of the particular difficulties of the process of teaching/learning gives origin, in *tutors*, to a sort of solidarity towards their teacher, thus improving the relationship with the latter.

From a cognitive point of view, this learning process is useful both for the *tutor*, who consolidates his knowledge (teaching is like "learning two times"), and for the *pupil*, who

receives an individualized lesson.

Considering the results collected by students, we can say that dialogue between peers provides a greater freedom and spontaneity, eliminating the tension and uneasiness often perceived by pupils in their relation with the teacher. In fact, the majority of students usually indicates in the fact that between classmates there is no fear in expressing perplexities and reservation the main cause underlying the success of the communication between pupil and *tutor* (answer b) to question n. 6). Another important aspect is usually seen in the fact that simpler words than those on the book or those used by the teacher are being used (answer a) to question n. 6).

The dialogue between peers thus becomes a tool facilitating the sharing of the objectives and the students' awareness of the attitudes leading to a failure, which must then be recognized and elaborated to overcome difficulties.

This is indeed a promising strategy because it encourages students to take charge of the problem of disciplinary recovery; it favors the assumption of responsibility in learning and reduces to a minimum that fatalist attitude which is often related to one's own failures in mathematics.

A sort of comparison between the two models

The main idea which underlies both *Peer Tutoring* and *Cooperative Learning* is the conviction that the assumption of roles in a group or a couple makes the pupils responsible for their own learning process, significantly favoring it at the same time. The goal of an educator, not only of the teacher, is that of succeeding in making *the other* assume the responsibility of a task.

The description of the two models in the previous sections has put in evidence that both the *Cooperative Learning* and the *Peer Tutoring* models aim to develop students' competence in assuming specific roles, balanced between the attention for disciplinary tasks and the care for interpersonal positive relations. Both the models, furthermore, suggest the teachers have a specific care for planning *metacognitive* tasks, which require students' reflection on what they did, what they are doing and how they could do better. It is also important that in any case students could have trace of the whole activity done: a sort of personal collection of works, of results, of reflections.

On the basis of our studies on experiences accomplished in secondary school, it seems that, as far as the *mathematical task* is concerned, *Cooperative Learning Model* is more adequate when

- the subject to work about is new and open to different paths of inquiry; for instance, when a new (i.e. not yet presented by teacher) demonstration of a theorem is required (Baldrighi, Fattori, Pesci, 2004) or when a complex problem situation has to be explored (Euler's formula for faces, corners and vertices of a polyhedra, Angelini & al., 2007);
- the task is quite difficult and the cognitive resources of the whole group of students are necessary; for instance when the problem is not familiar for students and a good expertise of the contents involved is required (Baldrighi, Bellinzona, 2004, Baldrighi, Bellinzona, Pesci, 2007)
- a subject studied a long time before has to be reminded; for instance, when the teacher plans to develop a mathematical content faced by students one year before or more, instead of asking directly to the students if they remember something or not, it is more fruitful prepare a task to accomplish in cooperative groups: it happens that in group is easier to recall appropriate terms, definitions, properties and the successive work of the teacher becomes more adequate.

Peer Tutoring model seems appropriate when a specific mathematical content has to be recovered only by a part of students, who showed difficulties. An inquiry activity based on peers' reflection on their own errors (wrong strategies or misconceptions) is very relevant for this model: in this case, mates' cognitive resources and peers' language could be fruitfully exploited. Experience makes it clear that not only students in difficulties are more likely able to recover (Torresani, 2008) but also that *tutor* pupils strengthen their competence in mathematics, their language abilities and their skills in interpersonal communication.

As far as the *social* and *relational* aspects are concerned, the difference is in the typologies of roles assumed by students in developing their collaboration:

- in the *Cooperative Learning* model, the students assume roles which are different at the social level (*the oriented to the task, the oriented to the group, the memory, the speaker and the*

observer) but they are involved in the same way in facing the problem posed;

- in the *Peer Tutoring* model, the difference is both at the level of roles assumed (*tutor* and *student*) and at the level of the way of facing the problem posed: in this case it is obvious that the *tutor* knows the problem and therefore his/her cognitive effort is more oriented to understand the strategies and difficulties of his/her *student*, rather than to propose personal solutions.

When a teacher is able to intertwine, during the educational process, both activities in cooperative groups and of peer tutoring, all the roles can be assumed by the students, and this is a very rich occasion for personal improvement, for all the students.

In conclusion, it seems relevant to recognize the peculiarities of these two teaching learning models, together with their analogies and differences, at least for two main reasons. Firstly, if a teacher has this awareness, his/her competence in planning didactical interventions could be more suitable and fruitful for improving students' education, both in mathematics and in interpersonal relationships. In addition, I believe that the same awareness could suggest to researchers in mathematics education deeper analysis of these two models and other points of view for further explorations.

References

- Angelini V., Nannelli P., Pesci A., Vitali E., 2007, Poliedri: non solo geometria, *L'insegnamento della matematica e delle scienze integrate*, Vol. 30A-B, 4, 355-396
- Baldrighi A., Pesci A., Torresani M., 2003, Relazioni disciplinari e sociali nell'apprendimento cooperativo. Esperienze didattiche e spunti di riflessione, *Matematica&Difficoltà 12*, Pitagora, Bologna, 170-178
- Baldrighi A., Bellinzona C., Pesci A., 2007, Una esperienza sull'intreccio di linguaggi per un uso consapevole di simboli matematici, *Matematica&Difficoltà 15*, Pitagora, Bologna, 60-65
- Baldrighi A., Fattori A., Pesci A., 2004, Un'esperienza di apprendimento cooperativo nella scuola secondaria superiore: il teorema di Pitagora, *L'insegnamento della matematica e delle scienze integrate*, Vol. 27B, 2, 125-145
- Baldrighi A., Bellinzona C., 2004, Esperienze di apprendimento cooperativo: le equazioni di secondo grado, *L'insegnamento della matematica e delle scienze integrate*, Vol. 30B, 2, 112-142
- Brousseau G., 1997 *Theory of Didactical Situations in Mathematics*, ed. and translated by N. Balacheff, M. Cooper, R. Shuterland, V. Warfield, Kluwer.
- Cohen E.G., 1994, *Designing groupwork*, Teachers College Columbia University, NY
- Cusi A., 2007, E' effettivamente possibile recuperare in matematica con le modalità correnti?, *L'insegnamento della matematica e delle scienze integrate*, Vol. 27B, 2, 125-145
- Damasio A. R., 1999, *The Feeling of What Happens, Body and Emotion in the Making of Consciousness*, New York/S. Diego/London, Harcourt Brace & C.
- Johnson D. W., Johnson R. T., Holubec E. J., 1994, *The nuts and bolts of cooperative learning*, Interaction Book Company.
- Pesci A., 2002, Mathematics teachers and students: how can we improve the human side of their relationship?, *Proc. 5th International Conference "The Humanistic Renaissance in Mathematics Education"*, Palermo, A. Rogerson (Ed.) 11-19
- Pesci A., 2004, Insegnare e apprendere cooperando: esperienze e prospettive, *L'insegnamento della matem. e delle scienze integrate*, Vol. 27A-B n. 6, 638-670
- Pesci A., 2007, From studies of cooperative learning practices towards a model of intervention on mathematics teachers, *Proceedings of CERME 5 (2007)*, Demetra Pitta – Pantazi & George Philippou (Eds), 1945-1954
- Sharan Y, Sharan S., 1992, *Expanding cooperative learning through investigation*, Teachers College Columbia University, New York.
- Topping K., 1997, *Tutoring. Insegnamento reciproco tra compagni*, Erickson, Trento
- Torresani M., 2007, Attività di tutoraggio nel recupero in itinere di Matematica, *Matematica&Difficoltà 14*, Pitagora, Bologna, 66 – 71
- Torresani M.C., 2008, Una esperienza di *Peer Education* finalizzata al recupero nella scuola secondaria di secondo grado, *L'insegnamento della matematica e delle scienze integrate*, Vol. 31 A-B, 6, 573-585