

The influence of fixed peer tutoring on student academic achievement: An experience in primary school mathematics

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Abstract: In recent years it has been observed that mathematics is the subject with the lowest results in Spain and Europe. Several authors indicate that this low performance is due, among other factors, to a traditional teaching approach. In this experiment, an experience of peer tutoring in the area of mathematics was carried out in a 1st grade classroom. The number of participants was 18, forming 9 pairs of students. A pretest-posttest quasi-experimental design was used with no control group. The effect of this methodology on students' academic performance was analyzed. The analysis of the results showed an overall statistically significant improvement in academic performance ($t\text{-test} = 3.11, p < .01$). The effect size associated with the experience was Hedge's $g = 0.51$. Despite the success of this experience, these results should be viewed with caution. The fact that this was an experience of short duration, with a small number of students and the absence of a control group should lead the reader to consider the final results of this work cautiously.

Keywords: peer tutoring; mathematics; primary education; academic achievement

1. Introduction

Mathematics has always been considered one of the most difficult or costly subjects in all educational stages in Spain. The PISA (Programme for International Student Assessment) reports show that, between the 2009 national and international student assessments, the lowest grades are in Mathematics (Wu et al., 2020). Among the many causes that give rise to this situation, a number of factors can affect this lack of performance. Among them, it is worth mentioning the problems in the design of an adequate teaching methodology (Jerim et al., 2020). Currently, the Spanish educational system is undergoing a process of educational transition. On the one hand, there are traditional methodologies, where students work on the basis of repetition of activities to memorize them and then apply them in an evaluation control. On the other hand, there are the innovative methodologies where emphasis is placed on meaningful learning, in which students cooperatively relate concepts to improve understanding and assimilation of content (Romero, 1997; McConnell et al., 2017). The origin of these innovative methodologies is largely based on STAD (Students Teams and Achievement Divisions) or Learning Teams by Divisions (Slavin, 1978), the beginning of what is currently known as Cooperative Learning or Learning Communities. This method mainly focuses on creating heterogeneous groups within the classroom where the evaluation is based on a scoring system among the whole group and not on an individual evaluation. This methodology is related to the topic to be developed next, peer tutoring.

1.1 Peer tutoring

This technique consists of training students in pairs, where the relationships between them are asymmetrical (one student adopts the role of tutor and the other of the tutored). The objective of peer tutoring is clear and at the same time common between the pair: the teaching-learning of contents from a well-defined and structured interaction (Xu et al., 2021). This methodology brings advantages to both participants. On the one hand, it benefits the tutor in terms of content mastery, reinforcing also his/her sense of responsibility and self-esteem. On the other hand, the tutor benefits from individualized attention tailored to his or her educational needs in a permanent and accessible manner (Healy et al., 2020).

1.2 Peer tutoring implementation

This methodology has some application phases, which must be followed for its implementation. These phases, according to Duran et al. (2019) are as follows:

1.2.1 Selecting and defining the pairs

Although it is possible to work with students from different grades, several authors indicate that peer tutoring is usually more effective with students from the same academic year (Moeyaert et al., 2019). In the case that we perform Peer Tutoring among students of the same course, it is very important to sort the students by proficiency level, divide the list in half and pair the students so that the "distance" is proportional (Arco-Tirado et al., 2020).

In addition, to facilitate the monitoring of the establishment of pairs and the continuous improvement of this method, it is important, not to say necessary, to stimulate monitoring from a technological point of view, i.e., to

take advantage of the benefits provided by ICT to improve the organization, approach and monitoring of this methodology (Martin et al., 2020).

1.2.2 Role training

It is necessary to deepen in the approach of the roles, since it is the key to the success of this technique, that is to say, it will be beneficial for both participants, a structuring of the session and a demonstration and experimentation of the different tasks (Campell et al., 2019). An important requirement to carry out a correct role formation is that the students participating in the peer tutoring have a similar language and vocabulary, that is to say, that the communication between them is fluid and that they have a capacity of understanding as well as possible. In this way, students will be more motivated, since they will work with greater comfort and ease (Hänze et al. 2018).

1.2.3 Monitoring of students

The pairs will need some time to learn to develop the respective role, in which it will be necessary for the teacher to offer feedback, and thus motivate the students to be consistent and move forward in critical moments. In addition, peer tutoring modifies the role of the teacher, allowing him/her to do what in the traditional way a classroom does not allow you to do: to attend individually or in pairs to those who request it and to make observations that allow to better understand the way in which students think and reason (Cantinotti et al., 2017). On the other hand, it is necessary to insist again on giving feedback to the students, so that they become aware of their partner's progress (both the tutor and the tutored), besides, the fact of supporting and getting more involved in what their students are doing, enriches the teacher a lot and justifies his presence in this method (Sytsma et al., 2019).

In addition to the above, there are a series of factors that are very important for the correct adaptation of Peer Tutoring. The most frequent problem is to think that couples will self-supply their needs by simply bringing them together. In order for the mentoring to be successful, the relationship between the mentor and the mentee must be specified in detail, in addition to prior training (Gottfried et al., 2019). On the other hand, it is necessary that at the beginning they have some practice time to adapt to the new roles, since at the beginning they are not used to exercise them. In addition, the teacher must offer feedback, both to the tutor and to the tutored, with regard to their progress in the process. (Hsu, 2019).

1.3 Previous peer tutoring experiences in mathematics

In the case of Fantuzzo (1990), the results showed that only by giving positive attention to group activities, it does not cause a significant improvement in the students' knowledge. However, what was not expected was that those students involved in this methodology obtained constant improvements in the performance of exact arithmetic, to a point where the test results of the experimental group were much higher than those of students who were not treated by this methodology.

In the experience conducted by Heller et al. (1992), they performed peer tutoring on elementary school students at high risk of school failure. Sixty-four students were randomly selected from a group of 80 4th and 5th grade students. These were randomly assigned from 4 conditions: structure + reward, reward, only structure and no structure + no reward. Results indicate that students who received both components showed the highest levels of accurate mathematical computations. Collateral measure analyses revealed that students in the reward conditions received higher reports of classroom behavior than students in the no-reward conditions. Students in the structured conditions reported higher levels of academic competence whereas self-control was enhanced in students whose conditions were unstructured.

2. Methodology

The methodology section includes the design, context, participants, previous questions, selection of pairs and the didactic unit.

2.1 Design

A quasi-experimental pre-test post-test with no control group was used (Damsa & Muukkonen, 2020). The variable under study was the students' academic performance. As for the instruments, focus groups (Ayala et al., 2018) were used to collect the students' opinions and an academic evaluation was carried out before and after peer tutoring.

2.2 Educational context

As for the context, the experiment was carried out in a public center of pre-school and primary education. It is located in the town of Castellon de la Plana, Spain. The school is located in the downtown area of the city. In the last decade, the area has undergone a great change in the socio-economic and cultural environment, characterized mainly by the arrival of immigrants with a low purchasing power, as opposed to the upper middle class families that predominated years ago. A clear example of this is reflected in the origin of the student body, where more than 50% of the students come from a foreign country.

The socioeconomic level of the families is generally medium-low, due to the recent incorporation of these in our country, the purchasing power of these families is conditioned by the labor quality of the same, which in some cases, at least one of the members is unemployed or works in temporary employment companies.

As for the socio-cultural level, due to the diversity of the class, this varies according to the students. In some cases, the students have a high cultural level, either because of their motivation and dedication in the different subjects, or because they have parents who are involved in their children's education, helping them in some tasks, attending meetings with the tutor periodically or participating in the school's cultural days.

On the other hand, the classroom has students with a more restricted socio-cultural level, their conception of education is quite different, limiting themselves to doing what is necessary to participate in school or class activities. In this case, the involvement of families is not as notable as in the previous cases. Absence from meetings with teachers or cultural events deteriorates the student's interest in school and learning. It should be added that some of these students participate in special educational programs such as: PT (Therapeutic Pedagogy), HL (Hearing and Language) and compensatory.

2.3 Participants

The classroom where this peer tutoring experience takes place is in the 1st grade of Primary School. In addition, this year something out of the ordinary has happened, since during the current academic year 2016-2017 new students have joined the class up to 5 times (from Eastern European countries, Latin America and Southeast Asia). Of the total number of students in the classroom, 68.4% come from foreign countries, while 31.6% are of Spanish origin. To begin with, the experiment will be carried out with 18 students, thus forming 9 pairs of participating students. As far as the academic level of the classroom group is concerned, it could be said that it is close to both extremes. Students with an exemplary academic level (both in the organization of work and in the assimilation of knowledge) will participate, as well as students with more educational difficulties, most of them participating in programs for children with SEN (Special Educational Needs) in the specialties of PT, AL and compensatory. It is worth mentioning that 27.8% of the students attend these programs. Generalizing in the mathematical level, the student body of 1st A can be divided in its totality in three groups:

- a) Group of outstanding students.
- b) Group with favorable capacities and notions in mathematics.
- c) Group with intermediate or unfavorable abilities and notions in mathematics.

Most of the students are in the second group. However, the synergy among classmates is good, that is, most of them relate positively and cooperatively.

2.4 First questions before starting the experience

Focusing on the students participating in the peer tutoring, some initial questions were raised that, throughout the process, have been resolved. These have been the following:

Is it possible to carry out this methodology with these students? Are they too small?

Is it advisable to restructure the classroom furniture in order to carry it out in only one didactic unit (with a 2-week time frame)? What happens with the newly arrived students who do not even know the language? Should we include them in the process?

Firstly, we should mention that, despite the scarcity of documents related to peer tutoring in the first cycle of primary school, it can be carried out with solvency, since the maturity of most of the students allows the classroom group as a whole to achieve the objectives set (Thurston et al, 2007). Secondly, with regard to the restructuring of the furniture, the classroom has double tables. This type of table provides us with the ideal situation to modify the structure and seat the pairs in an effective way. It should be noted that peer tutoring is a methodology where the improvement in the results is seen in the medium/long term, since all significant learning requires a cognitive change, which implies a long period of time (Velasco et al, 2009). Therefore, it is of vital importance that, in the didactic unit to be worked on, the students are positioned appropriately, thus restructuring the classroom furniture.

Finally, the last question has been the most complicated to clarify. It should be emphasized that the experience is going to be carried out through the subject of Mathematics, therefore, the linguistic level of the students does not have to be strictly high, this is not to say that these people will not communicate, in fact, through the exchange of ideas, students with some difficulty in the language take advantage to improve communication with their classmates. In other words, what at first may be a problem can be used as an opportunity to improve the expression and comprehension of the language in some students (Tomlinson, 2005). However, the transversality of the subjects requires a basic linguistic knowledge when solving certain aspects of the subject, for example, when putting into practice problem solving (Godino and Font, 2012). For this reason, special care will be taken with pairs where one of the members does not have the basic knowledge of the language for this educational stage. Thus, it will be necessary for the teacher to intervene more times than stipulated to support and consolidate the knowledge.

2.5 Training and selecting the pairs

Focusing on the students participating in the peer tutoring, the main criteria used to select the pairs were the students' logical-mathematical knowledge and mathematical competences, thus, a list was structured from the student with the highest score to the student with the lowest score. Following the criteria of Duran et al. (2019) to carry out the selection of pairs, the results were as follows. Through the arithmetic mean, the following list has been formed (see Table 1).

Table.1. showing previous students' average grades

STUDENT NUMBER	AVERAGE SCORE
A	9.8
B	9.4
C	9.3
D	9.2
E	9.1
F	8.6
G	8.6
H	7.7
I	7.6
J	7.4
K	7.1*
L	7
M	7
N	6.5
O	5
P	4.5*
Q	2.6*
R	2.5*

*Students who have not taken all the exams or have recently come to the class.

When establishing the pairs, the procedure was followed as indicated in the theoretical part of the work. The students were ordered by level of competence, and the list was divided in half, thus pairing the students in such a way that the "distance" between them is proportional (Duran et al., 2019).

Dealing with 18 students, 9 pairs will result where the tutors and the tutored have already been defined. These have been the following (see Table 2):

Table.2 . showing pairings of tutors and tutees

TUTOR	TUTEE
Student A	Student J
Student B	Student K
Student C	Student L
Student D	Student M
Student E	Student N
Student F	Student O
Student G	Student P

Student H	Student Q
Student I	Student R

For a better identification of the roles, a red card has been placed on the left side of the double tables, indicating that the students seated on that side will assume the role of "Tutor students". On the other hand, those seated on the right side of the table will assume the role of "Tutored Students".

2.6 Duration of the experience

Each session lasted 45 minutes, with a total of 5 math sessions per week. Every day a session was held except on Wednesday when 2 sessions were held back to back. Therefore the didactic unit that was developed during the peer tutoring program lasted 9 sessions plus the day of the exam.

2.7 Mathematics contents

The following are the contents worked on during the peer tutoring program.

- Comprehensible reading of statements.
- Identification of the number and type of operations to be performed to solve a problem.
- Identification of relevant and non-relevant data.
- Placement of data in an orderly manner to perform operations.
- Expression of mathematical reasoning.
- Addition by taking digits
- Sums of two numbers
- Formation of decreasing numerical series
- Mental arithmetic: adding and subtracting one-digit numbers.
- Solving addition and subtraction problems

2.8 Materials and resources

The materials and resources available for the teaching-learning process are as follows:

1. Digital whiteboard: a resource that has been used to help assimilate the contents to the students through new technologies.
2. Textbook: Having it as another resource, avoiding focusing the unit on it.
3. Worksheets: Throughout the unit they have been provided with worksheets to review and clarify doubts. Some of them are self-made. The aim was to provide the students with a closer resource when doing the activities related to the unit. It should be added that the worksheets have been created based on a transversal theme present in other subjects, in this case, "Mammalian animals". A section of the "Unit 7 of Natural Sciences" (taught in parallel to this subject).

In addition to the above, the students were provided with manipulative material to facilitate the understanding of the procedures in the activities and to improve problem solving. This material was created by the students themselves in the subject of Plastic Arts and consists of sticks. On the one hand they had groups of 10 sticks, representing the tens, and on the other hand single sticks, representing the units. Thus, the tutor and the tutee will check that the sum is well done. In addition, the tutor will ask the tutee a series of questions, thus proving that he/she has understood the procedure well.

Prospective teachers are at risk for making poor dietary choices that can cause significant health problems. They are unaware of the nutritional requirements to maintain a healthy body weight, they make poor nutritional decision, which can cause poor weight management and health problems. Prospective teachers select food according to convenience, taste, time, and price rather than nutritional values. Poor nutrition due to unhealthy eating habits may lead to delayed puberty, nutrient deficiencies and dehydration, menstrual irregularities, poor bone health, increased risk of injuries, poor academic performance and increased risk of eating disorders. The student teachers who are nutrition under eaters may be affected by anorexia or bulimia. Prospective teachers who do not eat breakfast, or eat an insufficient breakfast, are more likely to have behavioral, emotional and academic problems at college. Prospective teachers who consume unhealthy foods can have trouble concentrating, become easily fatigued, listless or irritable and are likely to face difficulties in learning, which can lead to behavioral and social problems. Teaching prospective teachers about the importance of good nutrition lay the foundation for a healthier and more fulfilling life. Poor eating habits and nutritional knowledge deficits may affect health of the youngsters. Healthy eating habits may help to eliminate carbonated soft drinks and unhealthy junk foods from their routine diets. The high intake of sugar rich and white flour foods such as cookies and cakes will increase the risk of obesity among college students. The significance of this research is to enlighten the prospective teachers about the importance of healthy dietary habits.

3.Results

3.1 Qualitative results

These were interviews conducted with two students in the classroom. The first interview was made to a student with the role of tutor and the second to a student with the role of tutoring.

It should be mentioned that these are transcriptions of a sound recording, therefore in many occasions, the dialogue between the teacher and the student will be created.

Interview 1 (Role: Tutor)

Q1: What do you think about the new way of teaching mathematics?

(Student): It is different from what we did before, because now we had to work as a team, and we had the partner next to us (Tutor and tutor)...

(Teacher): And you could talk to each other, couldn't you?

(Student): Yes, and we helped each other. That's something we were rarely allowed to do before.

Q2: How did you like being a tutor? How did you feel?

(Student): Good.

(Teacher): Do you think you have taught your classmate?

(Student): Yes, sometimes it was a little difficult, because I have never been a teacher, but in the end, I got used to it and got him to learn.

Q3: Did you like the activities we did? (Referring to some of the more manipulative activities, etc.)

(Student): Yes, I like it, because it was a new thing we hadn't done, so it was more fun to do sums and problems where we all show up.

Q4: Do you think you have improved or, on the contrary, have you learned less than you expected? (Student): Yes, I have learned to do addition while carrying. At first I was a little scared of them, but little by little I got better at them.

(Teacher): What about your classmate, do you think he has learned with you?

(Student): Yes, I have been able to teach him "little tricks" that I used to do the sums. At the end he did them as well as I did!

Interview 2 (Role: Tutor)

Q1: What do you think of the new way of teaching mathematics? (Student): It's very good and it might help a lot of kids in other classes. (Teacher): Ah how interesting... And you, did it help you?

(Student): Yes, besides, you told me the other day that I was doing great sums.

Q2: How did you like being a tutor? How did you feel?

(Student): Very good, but sometimes I feel ashamed to ask my classmate, so many times (Teacher): Man, no way! He already knew that you would ask him questions, and he agreed to help you as much as possible.

(Student): But also, when he told me to help him, I helped him, because maybe there was something he didn't know and I did.

Q3: Did you like the activities we did? Or did you like working as usual?

(Student): I like doing all the things because I can learn more and get smarter.

(Teacher): Sure, but are you more motivated to have traveled to the safari to do sums, or to do a problem about "how many candies does the shopkeeper sell...", for example?

(Student): I am motivated by both because I like candy but I also like the Safari.

Q4: Do you think you have improved or, on the contrary, have you learned less than you expected? (Student): Yes, I had a lot of fun doing addition, and thanks to my partner and you I was able to do the sums well.

(Teacher): Do you remember the chopsticks card? That day you saw how well you did your sums. (Student): Oh yes, that day I did them all well, I also helped my classmate to do some of the sums. (Teacher): Very good, that's how I like it!

3.2 Quantitative results

- Follow-up of the pairs:

One part of the evaluation consists of the behavior of the pairs throughout the didactic unit. How they have solved the day to day problems, and if they have worked together with their partner. It will be evaluated: Excellent (E) - Good (G) - Insufficient (I). And it will count for 30% of the unit grade.

- Pre-control test:

On the same day of the individual control (May 19) the pairs of the class did a "pre-control" test (pretest) to observe the improvements (or not) of their partners.

Mention that the students co-evaluated each other, correcting each other's test and noticing the things they had done right and wrong. (10%)

- Control test:

This was the final test (posttest), but not for that reason the most important. Obviously this was to test whether the students had grasped the concept of addition well, or whether they had failed to solve them. (60%)

The pretest and posttest scores for each student are shown below in table 3.

Table.3 . showing quantitative results for each student

STUDENT	PEER TUTORING EXPERIENCE	PRETEST	POSTTEST
A	E	10	10
B	E	10	10
C	E	9.8	9.9
D	G+	10	9.5
E	E	10	10
F	G	8.5	8
G	G	9	8.3
H	G	8	7.6
I	E	9.5	9.6
J	I	8.4	7.6
K	G+	8.9	8.7
L	E	9.8	9.8
M	G	8	8.1
N	G+	7	7.4
O	E	9.6	9.7
P	I	6.2	6.09
Q	I	1	2
R	G	7	7

An analysis using Student's t test for related samples indicated that the difference in academic performance due to peer tutoring was statistically significant ($t= 3'11$, $p< 0.01$). The effect size was Hedge's $g = 0.51$.

Table.4 . showing overall quantitative results

	Pretest	Posttest
Average score	7.16	8.29
Standard deviation	2.22	1.98
Participants	18	18

4.Discussion

The qualitative results are consistent with previous research on peer tutoring. Thus, as indicated by the previous works of **Alegre-Ansuategui and Moliner-Miravet (2017)**, **Moliner and Alegre (2020a, 2020b)**, **Santhanalakshmi (2021)**, students tend to enjoy peer tutoring at the same time as they learn. Thus, their qualitative opinions regarding this type of experiences, as expected have generally been very positive.

Regarding quantitative results, as expected from previous research in the field (**Alegre-Ansuategui, 2018; Alegre et al., 2019a; Moliner and Alegre, 2020c; Maldonado-Cid, 2021**) there were statistically significant improvements in students' academic performance. However, the effect size obtained is appreciably smaller than would be expected for this type of intervention (peer tutoring in mathematics) at this educational level (primary education) as pointed out in the review carried out by **Alegre et al. (2019a)**. Among the reasons that could be mentioned as possible causes of this smaller effect size would be the short duration of the experience, the absence of a control group or the small number of students (**Alegre-Ansuategui et al., 2018; Alegre et al., 2019b**).

5. Conclusions

This has been a group where the pairs have prospered in a positive way, most of them working adequately. However, there have been students who, at first, did not agree with this type of methodology, refusing to cooperate with their partner. Through a deeper and more detailed explanation of the methodology and its subsequent improvement in the results of the activities, they have managed to understand that it is a new way of working. Thus, little by little they have been introduced to this methodology, and the pairs have ended up working well.

Another setback regarding the pairs has been the absence of a student (missing 4 of the 10 days of the didactic unit). Therefore, his partner (who had the role of tutor), has lacked his tutor during this period. However, he has been given the necessary help to keep up with the group. And after the incorporation of his partner, he has managed to consolidate the procedure of sums by carrying out the activities and explanations worked on the previous days.

In general, it has been a positive experience, both for the teacher and the students. Among other factors, the results have shown that most of the participants have improved with respect to previous evaluations. Even so, these results should be viewed with caution. The fact that this was an experience of short duration, with a small number of students (18) and the absence of a control group should lead the reader to consider the final results of this work with caution.

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