The effects of a cognitive pathway to promote class creative thinking.

An experimental study on Italian primary school students

This is a pre-print version for the full version use the link:

https://doi.org/10.1016/j.tsc.2018.12.002

Abstract

The goal of this experimental research was to demonstrate that creative thinking could be trained in primary school children. After asserting the difficulty to determine a unique definition of creativity – the concept fits to several fields and areas of interests – the capacity to produce numerous ideas and to think divergently was chosen as the framework within creativity as a way of thinking that can be assessed and measured. Even though creativity is challenging to define and consequently to operationalize, tests exist with the purpose to evaluate creativity levels in individuals. Starting from the Test of Child Creativity (TCI) an Italian mental reactive aimed at measuring the potential of creative thinking in individual children, a Group Creativity Assessment (gTCI) was made up with the objective to test 224 children belonging to 10 primary school classes (5 second grades and 5 third grades), achieving creativity scores of groups. The aim was to investigate whether children's attitude to think divergently would improve after participating in a creativity training made up of 10 interactive one-hour long sessions. For that reason, all the sample of children were tested in T0 before the training; afterward 8 out of the 10 classes were weekly trained, before being all 10 classes tested again in T1, 10 weeks after T0. The hypothesis was that the trained classes would have improved in creative thinking, whereas the control groups would have not. It was therefore demonstrated the efficacy of the specific technique to train creative thinking that was conceived, developed and administered to the children.

Keywords: Creativity; Teaching; Divergent Thinking; Cognitive Training; Primary school

1. Introduction

1.1. Creativity as a way of thinking

«There is no doubt that creativity is the most important human resource of all. Without creativity, there would be no progress, and we would be forever repeating the same patterns», writes Edward De Bono (De Bono, 1992). What is creativity? How can it be defined? It may be generally perceived as a talent, a characteristic of eminent artists, a distinctive and innate personality trait of few human beings. However, creativity can be conceived as an ability belonging to all human beings and to all areas of knowledge, instead of being restricted to certain specific subjects like visual art and music. The present research aims at testing whether creative thinking can be trained in everyone.

Creativity is a multidimensional construct. As such, it is difficult to reach a unique and universally recognized definition. In psychology research it is typically defined as the process leading to the generation of products that are new, original, useful, and effective (Runco & Jaeger, 2012). A creative mind is capable of imagine innovative answers to questions, and it is characterized by flexibility and plasticity. These can be defined as the ability to generate ideas that are different from each other, and the quality of being easily shaped or moulded, respectively. Creative thinking can thus be considered as the ability to generate new concepts or solutions (De Bono, 1970). The thinking processes underlying creative answers are based on the person's skills, knowledge, understanding, motivation, and emotions (Ferrari, Cachia, & Punie, 2009; Vygotsky, 2004).

However, to provide a wider frame of creativity, it is necessary to refer to several defining models, each capable of highlighting particular aspects, or dimensions, of the construct. In particular, Rhodes (1987), in the attempt of providing a complete framing of creativity, proposed to classify models based on the focus on (a) the person who creates, (b) the cognitive processes involved in the creation of ideas, (c) the environment in which creativity occurs, and (d) the outcome of the creative activity.

Focusing attention on the cognitive processes involved in creativity, the Guildford's model (1957) collocates the creative thinking within the interaction of specific aspects of cognition. In particular, Guilford described two possible ways to produce thoughts: the convergent thinking and the divergent

thinking. The former is the processes involved when we face known problems and we can use the acquired knowledge or methods to arrive to a conclusion. The last refers to the ability to create new ideas starting from an input. It can also be viewed as a creative cognitive style or creative potential (Silvia et al., 2008). Children seem to develop this ability around 2 years (Bijvoet-van den Berg & Hoicka, 2014). Divergent thinking is the opposite of functional fixity that occur when a routinized way of thinking inhibits new ideas, leaving the thinker with just a few ideas linked to previously tested solutions. Divergent thinking has the following components:

1. Fluency: Fluency may be defined as the ability to generate new solutions about new or ambiguous problems in a short time

2. Flexibility: the ability to simultaneously propose different perspectives on a given problem;

3. Originality: the ability to produce ideas not previously developed by the individual;

4. Elaboration: the ability to systematize and organize the details of an idea and use this information to carry on a task.

Divergent thinking is a good predictor of creativity, generally better than intelligence as measured by IQ tests (Runco, Millar, Acar, & Cramond, 2010). Regarding the nature of the task, Teresa Amabile has highlighted how understanding the nature of the task is a fundamental process for creativity (Amabile, 1996). In fact, the task must trigger a heuristic approach to a given problem so that the solution can be creative. On the contrary, under strictly regulated routine behaviours (which we could define routine tasks) there can be no creativity, since it is enough to follow step by step the instructions contained in the available cognitive algorithms. This condition, typical of many working and educational contexts, allow fast responses and a linear learning process, but is also a constraint to creativity (Amabile, 1998; Runco, Acar, & Cayirdag, 2017).

Munari, an Italian artist, designer, writer, and educator, asserts that in order to develop creativity and imagination in a child, he/she should memorize as much information as possible in order to make more connections between things, so to approach problems as well as everyday life. Munari believes that the extent and breadth of childhood experiences influence the development of creativity and

thinking scope of a person (Munari, 1977). Also, Rogers affirms that genuinely creative adaptability represents the only possibility that humans have to face the kaleidoscopic change in their world (Rogers, 2012).

1.2. Creativity as a learning objective

Human creativity has been an interest to psychology and education science for generations (e.g. Guilford, 1959) and it has been recognized as an essential skill (May, 2015) and a key educational goal that should be supported in schools (Antonietti & Cerioli, 1992; Chan & Yuen, 2014).

The Organisation for Economic Cooperation and Development (OECD) highpoints creativity as one of the most important learning goals for the 21st century (Lucas, Claxton, & Spencer, 2013): schools should prepare students for a future that will request creative thinking in order to face the multifarious and complex problems that our future society will disclose. The future of our civilization, according to Sir Ken Robinson (Robinson, 2011), depends upon the creative capabilities of young people. Consequently, the education system should strengthen personal and individual attitudes and inclinations and avoid encouraging standardization: «If you run an education system based on standardization and conformity that suppresses individuality, imagination and creativity, don't be surprised if that's what it does» (Robinson, 2015).

It is important to consider that creativity may be referred to artistic expressions, to scientific progress, to complex problem-solving or to daily activities. In this sense, creativity research refers often to the dichotomy "big-C" versus ''little-C" (Kaufman & Beghetto, 2009). Little-C is a characteristic of everyday creativity and is a fundamental ability for human to survive. It is useful or even indispensable in many aspects of life, from decision-making to behavioral procedures (e.g., inventing a story to go out at night, finding a parking for your car, or decorating). Little-c creativity is thought to be accessible by nearly everyone and commonly distributed in the population (Kaufman & Baer, 2006; Sternberg, Grigorenko, & Singer, 2004).

Big-C creativity, instead, refers to eminent examples, e.g. the Divine Comedy by Dante Alighieri o la Guernica by Picasso. Big-C creativity implies achievement that only a select few will reach in their life. It is clear that an educational training must be aimed at promoting little-c creativity. However, this product-oriented distinction is not very useful for our aims, since we are not interested in evaluating a visible product. Instead, the aim should be to stimulate the ability of children to be involved in a task where they can develop new interpretations and perspective of an event so to promote fluent and flexible ideation. In this sense, we are interested in the so-called mini-c, that may be described as the ability to interpret the experience in a personal way, instead of just acting or reacting to it (Beghetto & Kaufman, 2007). The mini-c construct is the focus of our study, since in a sociocultural framework it may be considered a particular way of constructing knowledge within a virtuous individual-social world interaction. Promoting mini-c creativity, then, can be useful to enforce different interpretation of a task in a given social context. So, it includes both the development of mental process and the engagement in a social activity. This is exactly what we did in our experiment. In fact, we wanted to promote mini-c creativity within the normal interaction in a classroom, with the hypothesis that fostering creativity in a social context will target two aims:

- Promote individual mini-c level
- Promote the creative performance of the class as a group

Consequently, for education purposes creativity may be best conceptualized not only as a personality attribute or as a general aptitude, but as a behaviour resulting from particular assemblage of personal features, cognitive abilities and social and learning environment (Amabile, 1983). Moreover, only few previous studies (see for example Alfonso-Benlliure, Meléndez, & García-Ballesteros, 2013; Cheung, 2012; Katz & Stupel, 2015; Lin, 2011; Tsai, 2013) highlighted the importance of creating an appropriate learning environment, especially aimed at promoting and supporting students' creativity. Moreover, a proficient data comparison and integration that could lead to more systematic shared practices is still missing.

1.3. Literature review: testing creativity

…

The best-known Italian creativity test is the *Test di Creatività Infantile* (TCI, *[Test of Child Creativity]*; (Antonietti & Cerioli, 2002), a psychological tool aimed at measuring the potential of creative thinking in children. Its structure follows from the verbal TTCT and it was developed as a test specifically adapted to the Italian cultural context. In particular, it was thought as an instrument to be easily administered in a primary school setting. The test measures fluidity, flexibility and originality in tasks of spontaneous production of ideas.

There is a number of studies validating creativity being a cognitive ability, not an intrinsic and fixed personal characteristic. Dealing with the possibility to measure creative thinking in children, the Department of Applied Social Studies of the City Polytechnic of Hong Kong carried out a study with the objective of determine the concurrent validity between activity-based measures of creative thinking and standard divergent thinking tests (Kitto, Lok, & Rudowicz, 1994). In order to do so, a sample of 30 fifth-grade children was chosen and five creative thinking abilities were measured using the behavioural techniques and the children's scores for fluency, flexibility, and originality were compared with those from the TTCT. Despite the small sample, the results indicate that the measures of fluency and originality on the behavioural techniques correlate highly with the scores of verbal fluency and originality on the TTCT, meaning that both the types of creativity measurements are acceptable and valid.

A study from the King's College of London (Hu & Adey, 2002) describes the development of a test of scientific creativity for students. Based on the experience of the TTCT, a 7-item scale for measuring scientific creativity was developed and validated through analyses of item response data of 160 secondary school students in England. The aim was to investigate the relative scientific creativity of students of different age and ability level: the results indicated that the scientific students' creativity increases with age and that science ability is a necessary but not sufficient condition for scientific creativity.

As said, previous studies assessed creative thinking in individual settings, but there are almost no practices of assessing creative thinking on groups of children. Furthermore, it is not usual to train creative thinking in primary school. The interest in human creativity seems to have not led to either substantial advances in the understanding of creative processes nor to theory-based techniques for enhancing human creativity. Even if in the past 20 years the relevance of creativity emerged as a need to improve students' curricula (Wyse & Ferrari, 2015), in the Italian schooling system there are no standard defined techniques or methods teachers normally use to assess student skills and talents.

To sum up, in this paper we suggest that creativity is potentially present among all people. At the same time, it is differently distributed in the population, as measured by the available tests, and depends on a number of physiological, psychological, social and contextual factors. Finally, and more importantly, it can also be fostered by specific training, as it will be shown in the following paragraph.

1.4. Literature review: training creativity

Since creative thinking is a competence that can be learnt and taught, creativity levels can be increased in young people by education and training. Research on the effectiveness of training creativity disclosed that using specific techniques and training programs could help to enhance the level of creativity among the students.

For example, academics from The University of Oklahoma completed a review of the effectiveness of creativity training (Scott, Leritz, & Mumford, 2004) using a quantitative meta-analysis on studies assessing creativity programs at school. The authors selected 70 prior studies based on the following criteria: the paper was considered if the analysis included only research focusing on creativity training, and not on general educational courses such as Arts. Also, the paper had to include a clear description of the procedures used for the training, as well as of the population involved. The study had to clearly describe the exact measures acquired to assess creative performance and the statistics procedures to assess effect size. Finally, those studies illustrating only general summaries or difference scores were discarded. The results of the meta-analysis revealed that creativity training

programs following the abovementioned criteria typically induce improvements in performances. An examination of the factors contributing to the relative effectiveness of these training programs indicated that more successful programs were likely to focus on development of cognitive skills.

Similarly to the present study, the School of Psychology and Human Development of the University Kebangsaan in Malaysia, carried out a study (Zahra, Yusooff, & Hasim, 2013) that explores the effectiveness of training creativity on preschool students, administering 12 sections of training creativity (Brainstorming, Tell Story, Web Link and Role Plays, Checklist and Torrance Training Creativity Test). Results showed positive significant differences between pre-test and post-test values, and a strong effect of training creativity on the preschool students.

1.5. Purpose of the present research

Previous studies were aimed at testing individuals on creative thinking, nonetheless only few studies targeted creative thinking on groups of children. The Italian schooling system is based on inclusivity, a policy about how classrooms, programs and activities are developed and designed so that all students learn and participate together at the same time. Consequently, training and assessing creativity at a group level may promote inclusiveness and prevent exclusions: that's why the idea was to test groups, and not to consider single students. We argue that it is vital to consider creativity at a group level, since many work and educational activities in Italy are implemented in this setting. Also, teamwork is considered a fundamental soft skill. Thus, an important target at school could be to foster group creativity, instead of individual creativity. In this way, the entire group will experience higher-level achievement, with direct positive effects on class performance and potentially indirect effect on the individual performance. Generally speaking, in fact, it was proven that when a group increases its achievements the benefits are both for the group (since many assignments need to be accomplished at a group level), and for the individual (since being part of a functioning group facilitates individual learning and increases the learning related self-efficacy; Moreland & Myaskovsky, 2000).

Thus, the purpose of the present study was to verify if creative thinking is an ability that can be trained collectively in a class. The research involved classes of three primary school in Milan, Italy. The aim of the research was to investigate whether children's attitude to produce numerous and new ideas would improve after participating in a creativity training made up of 10 interactive one-hour sessions, carried out for 10 weeks, once a week. The main factor that was observed is the capacity to produce ideas, which was measured and analysed in the groups before and after the 10-week training period. The hypothesis was that children belonging to the trained classes would improve in creativity, whereas the others, belonging to the control groups, would have not, meaning that creative thinking is an educable attitude not depending only on time.

2. Materials and Method

2.1 Participants

The sample consisted in 10 classes including 224 primary school students, 112 boys and 112 girls. 119 of them were second grade students while 109 were third grade students. Children in second grade were born in 2010 and third graders were born in 2011. The Italian primary school system starts at 6 years of age (1st grade) and lasts for five years. The average number of students in the classes was 22.4 children (S.D = 2.32). The students belonged to 3 primary schools in the urban area of Milan, Italy: 2 public schools and a private one, within the compass of 8-10 km. For privacy reasons, the generalities, backgrounds and social and occupational category information regarding the students' families were not collected in the experiment, but it can be assumed that children attending private school are more likely to belong to wealthier families comparing to the ones attending public schools. The composition of the sample was the following: 147 students were Italian, whereas 77 children were born in other countries (not native Italians) (see Table 1). The study was approved by the school council and communicated to children parents, who signed the informed consent. The study was evaluated approved by the local ethical board.

Insert **Table 1** about here

2.2 Procedure

At the beginning of the study (T0) all the classes of the sample (5 second grades and 5 third grades) were tested (baseline pre-test) with a preliminary assessment. During the 10-week training between T0 and T1, 8 out of the 10 groups were trained (Training classes, T), whereas the remaining 2 just followed the standard class activities without a specific training (Control classes, C). At the end of the training period (T1), all the classes were re-submitted to the cognitive assessment to directly explore if and how the training produced any effect on creative skills.

2.3 Creativity Assessment

…

Describing the sub-tests in detail, the Examples trial asks the students to name all the objects with specific features they could think about: a colour (green in the PRE, blue in the POST), a shape (squared in the PRE, rounded in the POST), a material (wooden the PRE, plastic in the POST). The Purposes trials was made up of 2 questions in which the children were asked to imagine all the different ways in which 2 objects can be used (chair / tissue in the PRE and pencil / box in the POST). Finally, in the Consequences trial, two different unusual situations were presented to the students and they were asked to think about all the possible consequences to those situations (If raindrops were as big as apples / If your classroom was a submarine in the PRE; If cars were as small as peanuts / If your house was an aircraft in the POST).

The duration of the gTCI was 25 minutes in each class, the same for the pre- and the post-training assessment. Specific timing for every set of questions is reported in Table 2.

Insert **Table 2** about here

The used gTCI differs from the TCI for two main elements that were modified: first, the test was proposed to the entire class environment and not to a single child at the time, in order to test the whole group. Secondly, a specific timing was set for every question (3 minutes/item) instead of giving the children an undetermined time to spontaneously answer, as for the original TCI.

The setting of the gTCI and of the training was the classroom itself. The children were seated in their normal places and no changes were asked from the daily routine disposition of the students and the ordinary work environment. Each series of answers was recorded on the blackboard, drawing a small vertical segment for each word every child proposed raising his/her hand. Each set of answers was scored, and the summation of the scores resulted in the total fluidity score for every group of questions (Examples, Purposes, Consequences). Moreover, a *Total number* of answers was calculated, summing up all words of the 3 subsections. The number of repetitions was also considered as a parameter to give an idea of how the children listen to each other: the more they pay attention to one another, the less they repeat words that have already been said by someone else. This behaviour could be considered an index for the extent to find original ways to solve the problem proposed. For every repeated word within the same question, a circle was drawn around the vertical line (Fig. 1a/b).

Insert **Fig. 1a/b** about here

2.4 Creativity Training

2.4.1 Description of the training

Two classes formed the control group (C) who was not subject to a creativity training: the teachers carried out the usual activities of the didactic curriculum for second and third grade. Eight out of the ten classes were instead weekly-trained (T). The study was carried out for a total of ten lessons, within each class. The 10 weeks teaching curriculum included a series of group games and exercises. The aim of the interactive activities was to induce children to produce new ideas, the ability to imagine multiple ways to use an object, and the capacity to think potential consequences to events. The training mostly consisted in dialogical sessions, maieutic conversations and ludic activities with the

students, included drawings. Every weekly session of the training lasted 60 minutes: each session had different starting point, unfolding and development. All the types of activities proposed to the children took the cue from simple objects, stories or subjects close to them, that were starting points for an imaginative and inquisitive work together. The 10-week training was not a propaedeutic course: the activities had no mean to teach some knowledge, but to train some competences. For this reason, the interactive sessions could be submitted in different orders in the 8 classes. In order to train children's creative thinking, no particular material was needed. The materials used were blackboards and chalks, paper, coloured pencils. The training did not involve tasks similar to the ones used to assess creativity in T0 and T1 (see Tab 3 for further details).

Insert Tab 3 about here

2.5 Data analysis

Statistical analyses were conducted on the fluidity of data collected from the entire sample in T0 and T1 by using IBM SPSS Statistics for Windows (Version 24.0). Two different orders of analysis were performed: the first step considered only the initial assessment (T0) to exclude the presence of significant differences in terms of creativity among classes before the training, especially between training and control groups. Then, the second step was aimed to directly assess the training's effect by comparing pre and post-training performance. Considering the small sample size and the statistical recommendations for this cases, non-parametric analyses have been applied (Gibbons & Chakraborti, 2010). Also, to compute effect-size, Cliff's delta values have been calculated (Cliff, 1993).

Step 1

The first set of analysis was completed in T0 before the training. Two non-parametric Mann–Whitney U tests were applied on the five dependent variables of interest: *Total Number* of words, *Examples* words, *Purposes* words, *Consequences* words and the number of *Repetitions*. The test

compared these scorings between the two levels of the two independent variables between subjects' variables: *condition* (2: training vs control), *grade* (2: second vs third).

1a) A first test was run on the variable *condition* in order to prove that there was no statistic significant difference between the performance of the training classes and those of the control ones.

1b) A second test was run on the variable *grade* with the aim of exploring if there were significant statistical differences between the performance of the second graders and those of the third graders before the training.

Step 2

The second set of analysis was carried out to demonstrate the efficacy of the training. Since we needed to analyse within-subjects values we opted for the Wilcoxon signed-rank, that allow to compare data coming from dependent samples, and repeated measures. 10 non-parametric W tests were applied to the 5 dependent variables of interest: *Total Number* of words, *Examples* words, *Purposes* words, *Consequences* words and the number of *Repetitions*. Independent variables included the within-subjects variable *time* (PRE; POST) and the between-subjects variable *condition* (training; control).

2a) The first 5 tests were run on the training group scorings in order to investigate the presence of a significant statistical difference between their performance before and after the training.

2b) The second 5 tests were performed on the control group scorings with the aim of excluding the presence of a significant statistical difference between their performance in T0 and T1.

3. Results

3.1 Step 1: Homogeneity (T0: PRE)

1a) No significant differences were observed in T0 concerning the PRE scores of the T classes if compared to the C classes. All the children of the different classes and schools appear to have similar starting point regarding their creative thinking attitude before the training.

1b) No significant differences were observed in T0 about the performances of second and third grade classes. In other words, the students in second grade exhibited no significant differences in their imaginative and creative abilities before the training compared to third graders.

Insert Table 4 and 5 about here

3.2 Step 2: Training Efficacy (T0-T1: PREPOST)

2a) The 5 Wilcoxon tests run on the training group revealed that in 4 out of the 5 dependent variables a significant statistical difference between T0 and T1 emerged (see Tab. 4 for descriptive statistics). *Total Number* scoring was improved after the training (M_{post}= 159.5; S.D. = 19.1) compared to T0 (M_{pre}=118,3; S.D. = 20.5), as displayed in fig. 2.

Insert **Fig. 2** about here

Examples scoring was improved after the training (M_{post}= 87.00; S.D.=11.7) compared to T0 (M_{pre}=64.00; S.D.=13.082). *Purposes* scoring was improved after the training (M_{post}= 43.5; S.D.=43.5) compared to T0 (M_{pre}=31.25; STD=4.5). *Consequences* scoring was improved after the training (M_{post}= 29; S.D.=4.81) compared to T0 (M_{pre}=23; S.D.=4). On the other hand, *Repetitions* did not display any statistic significant difference between PRE and POST scores.

2b) The 5 Wilcoxon test run on the control group revealed that in none of the dependent variables a statistic significant difference between the performance of the children in T0 and T1 was observed (see Tab. 6).

Insert Tab 6 about here

For all the significant results, we found good effect sizes (as reported in Tab. 6). These indices support the presence of large effects of the independent variables on the observed measures.

4. Discussion and conclusion

The present study aimed at demonstrating the educability of class creative thinking in second and third grade students. In order to do so, a cognitive training was proposed to the training groups, composed by 8 classes, with the intention to achieve collective group scores, and not individual ones. The efficacy of the 10 week-creative thinking training administered to the children was demonstrated through the statistical analyses.

4.1 Group assessment int T0

As revealed by the first set of analyses performed in T0, all the classes involved were similar in T0 for creativity scores. The two Mann–Whitney U tests, in fact, revealed the absence of any significant differences between training and control groups and between second and third graders before the training. Therefore, it is possible to assume that there were no differences in the level of creative attitude between children of different ages. The absence of any significant difference between the classes assigned to the control and the training group was fundamental to demonstrate that the improvement in T1 was actually an effect of the training.

4.2 Assessing training's efficacy

The results of the Wilcoxon signed-rank comparing T1 and T0 scorings demonstrated the efficacy of the training, showing that only the training groups' performances widely improved, whereas the control classes showed no statistical differences between pre and post assessment.

For the training groups, the analysis on *Total Number* of words showed a significant improvement in the ability to produce ideas in the entire sample. A very similar effect can be observed in the Examples scores (fluency), that is the number of answers given to the first 3 questions (color, shape, material). A significant increase, even if less pronounced, was also found for the Purpose and Consequences scores, probably because those questions were more difficult than the previous ones. The *Repetitions* variable did not display any significant statistical difference in T1 after the training, differently from what was expected. The number of repetitions decreased, but not enough to reach statistical significance.

As described in the Introduction, creativity can be seen as a particular assemblage of personal features, cognitive abilities and social and learning environment (Amabile, 1983). The absence of statistically significant change of *Repetitions* might highlight that some social-collective aspects like listening to each other and cooperate in learning request more time and longer training in order to show significant improvements, compared to some cognitive factors, such as creativity by means of the production of multiple ideas (Runco & Jaeger, 2012). As a future perspective, it would be appropriate to lengthen the lasting of the training in order to verify if the variable *Repetitions* would decrease in a significant way, together with other interpersonal variables, such as empathy, prosociality, mentalization and theory of mind. Concerning the control groups, the analyses revealed no statistically significant difference between the performance of the children in T1 and those in T0. The students in the control groups were not trained and, as expected, there were no significant improvements in the answers of any of the set of questions of the gTCI. The control groups' performances concerning the *Total Number*, *Examples*, *Purposes*, *Consequences*, *Repetitions* scores remained unvaried in T1, demonstrating that the evident change displayed in the training group's

results was an effect of the cognitive pathway to promote creative thinking that was offered to the students.

4.3 Limitations and future perspectives

To conclude, the present work provided initial evidence of a possible positive effect of a cognitive training on fluency and idea generation in primary school children. The research and its possible evolutions could give a substantial contribution to the future of learning and teaching within a creative framework. Also, it could provide new insights and ideas to other scholars, researchers and teachers to promote innovation towards teaching for thinking. Future research should also target the relationship between an improved class creativity and education achievements. Though, creativity may be considered as transversal skill which is useful despite of any educational goals, it could be interested to find out how promoting divergence might impact with one's school trajectory. Indeed, several studies target the correlation between creativity, personal achievements, QI and other individual parameters (e.g. Kim, 2011), but there is poor evidence about how it is possible to increase school performance targeting creativity, also because individual features, such as personality traits, might heavily modulate the results of interventions (Entwistle & Ramsden, 2015). In this sense, our approach that targets class instead of individual creativity, might be easier to apply, since it would be possible to evaluate the impact of targeted creativity intervention on class performance.

Future research needs to confirm and extend our results also considering the present study limitations. First, the test we used was previously validated for individual settings, while we adapted it to a group setting. This adaptation requires further attention, so to assess the relationship between group and individual measures of creativity and to prove the validity of the adopted procedures. Furthermore, it would be convenient to increase the number of classes involved, differentiating the sample including both different grades (adding 1st, 4th and 5th grade) and different types of educational approach (e.g. Montessori, Steiner, etc.). This could be important to track changes through age and to verify if the method can affect creativity levels and in which ways. Moreover, it

could be interesting to assess such variables through a longitudinal study, to monitor the effects of the training and the progress of creative thinking step by step, as well as other possible variables of interests such as family's demographics, but also children's personality.

Finally, it would be interesting to diversify the training pathway, using different methods (or different pedagogical approach), to explore the effects of each technique to determine which one can better enhance creativity, in which educational frame, and at which age.

Artwork

Table 1: Samples' composition.

Class #	Grade	Condition	Children	Boys	Girls	Non-Italian native speakers
1	second	Training	26	13	13	0
2	second	Training	23	12	11	11
3	second	Training	23	12	11	15
4	second	Training	24	12	12	11
5	second	Control	23	12	11	7
6	third	Training	25	13	12	0
7	third	Training	20	11	9	10
8	third	Training	20	9	11	7
9	third	Training	19	7	12	5
10	third	Control	21	11	10	11

Table 2: gTCI session Timetable

Introduction and brief explanation of the gTCI		**4 minutes**
First step	**EXAMPLES**	**9 minutes**
1 a	Color	3 minutes
1 b	Shape	3 minutes
1 c	Material	3 minutes
Second step	**PURPOSES**	**6 minutes**
2 a	Object #1	3 minutes
2 b	Object #2	3 minutes
Third step	**CONSEQUENCES**	**6 minutes**
4 a	Situation #1	3 minutes
4 b	Situation #2	3 minutes
Total time		**25 minutes**

Table 3: Sessions proposed to the children

The following table 4 shows titles and the main objective of each of the ten workshops that were proposed to the classes belonging to the T-group. All the 1 hour-long sessions were designed as games/stories in which the children of the class were involved collectively and orally. Some workshops were fully oral; some others involved a graphic session.

	Title	***Objective: training of***	***Procedure***
1	*The Imaginary Planet*	Imaginative processes	We asked children to imagine a brand new planet, different from the existing ones, and to draw on the blackboard while they described it: how is it made? What color and shape is it? Who lives there? What do they eat, drink, do...? etc. We asked them questions about what they said and adopted an inquisitive attitude regarding the topic.
2	*How did it end up there?*	Divergent thinking on space and time	We presented to the students an unusual situation: there is a penguin in the desert. We then asked them to imagine and explain all the different possible reasons why the penguin ended up there, what was it doing and why, motivating every solution.
3	*Impossible words*	Verbal creativity	A series of cards are given to the children: each one has an "impossible word" that is a made up vocab that does not exist. Children are asked to come up with all the possible different meanings for that word.
4	*Fight and reconcile*	Mind reading	We drew two sad children on the blackboard and told the kids that they have argued but we do not know why. First, the children were asked to imagine some reasons why they could

			have argued. Then we asked them to imagine and explain all the possible ways in which they could reconcile.
5	*The Seashell*	Sensory play and idea generation	We brought children a bag with two seashells hidden inside, and we asked them to guess what there was inside the bag, hearing the noise, looking at the shape, touching it etc. After 10 minutes of guessing, we showed the seashells and encourage the kids to smell them, listen into the holes and describe an imaginary situation.
6	*Letters and Numbers*	Vocabulary and creating a story	The children were asked to choose a random card in a deck of numbers and letters. They are encouraged to come up with a certain number (number card) of words starting with a certain letter (letter card), and combining them with some other new vocabs we gave them, creating stories.
7	*The Chestnut in the Tree*	Imagination and narration	We showed to the class some images of a story: there is a tree with a chestnut hidden under the leaves. A series of animals try to climb the tree in order to catch the chestnut but it is hard because they find obstacles on their way. How can we help them?
8	*Creative Stories*	Divergent thinking on visual cue	Starting from some graphic signs, the students were encouraged to think about possible objects, people, animals those signs could become, combining them and discussing each other in order to come up with the best solution.
9	*What if…?*	Capacity to think unusual solutions	We presented to the students many different strange and unusual situations by using the form sentence: "What if....?".

			For example: what if your bedroom was a ship? And then asked them to imagine all the possible consequences.
10	*Dices*	Capacity to create stories by combining visual cues	We rolled some dices representing figures of objects, people, and animals. We ask students to create a story using all the faces of the dices, in the order they like.

Table 4: Descriptive analyses

	Scorings T0	**Scorings T1**
Controls Classes		
Examples	M=50; SD=1.4	M=51; SD=4.2
Uses	M=31.5; SD=2.1	M=30; SD=1.4
Consequences	M=24; SD=5.7	M=21.5; SD=2.1
Total words	M=105.5; SD=6.4	M=102.5; SD=7.8
Repetitions	M=2.5; SD=2.1	M=4.5; SD=2.1
Training Classes		
Examples	M=64; SD=13.4	M=87; SD=11.7
Uses	M=31.3; SD=4.5	M=43.5; SD=6.3
Consequences	M=23; SD=4	M=29; SD=4.8
Total words	M=118.3; SD=20.1	M=159.5; SD=19.1
Repetitions	M=5.3; SD=1.2	M=4.1; SD=2

Table 5: Homogeneity Test (T0)

Statistical significance showing that at T0 no significant differences emerged between C and T groups (a), and between 2nd and 3rd graders (b).

	p value
C vs T groups	
Examples	0.4
Uses	0.9
Consequences	0.7
Total words	0.4
Repetitions	0.1
2nd vs 3rd graders	
Examples	0.5
Uses	1
Consequences	0.8

Total words	0.8
Repetitions	0.1

Table 6: Training Efficacy (T1/T0)

	p value	**effect-size**
Control Classes		
Examples	0.7	-
Uses	0.2	-
Consequences	0.3	-
Total words	0.2	-
Repetitions	0.7	-
Training Classes		
Examples	0.01	0.578
Uses	0.01	0.591
Consequences	0.01	0.593
Total words	0.01	0.875
Repetitions	0.1	-

Fig. 1a, 1b

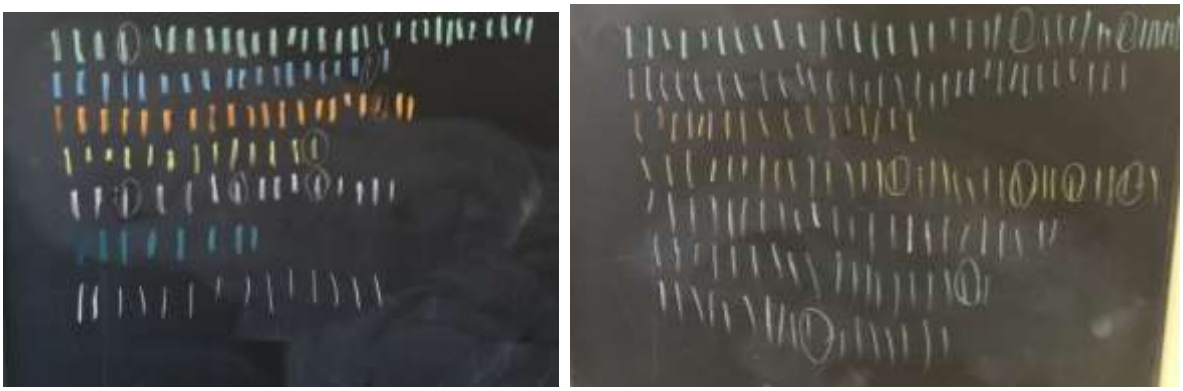

Fig. 2

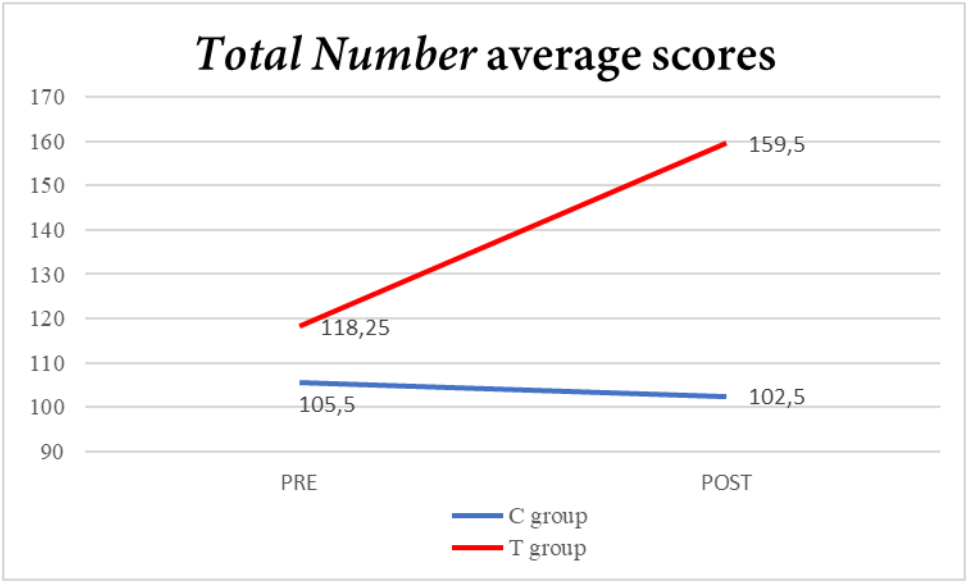

Figure Captions

Fig. 1: Picture depicting the number of answers recorded on the blackboard at pre-training **(a)** and post-training **(b)** in a second-grade training class.

Fig. 2: *Total Number* average scores of the training (T) and control group (C).

References

Alfonso-Benlliure, V., Meléndez, J. C., & García-Ballesteros, M. (2013). Evaluation of a creativity intervention program for preschoolers. *Thinking Skills and Creativity*, *10*, 112–120. https://doi.org/10.1016/j.tsc.2013.07.005

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology*, *45*(2), 357–376. https://doi.org/10.1037/0022-3514.45.2.357

Amabile, T. M. (1996). *Creativity in context: Update to the social psychology of creativity*. Hachette UK.

Amabile, T. M. (1998). *How to kill creativity* (Vol. 87). Harvard Business School Publishing Boston, MA.

Antonietti & Cerioli. (1992). *Sviluppare la creatività infantile a scuola: Un contributo sperimentale.* (IRRSAE Bas).

Antonietti & Cerioli. (2002). TCI - Test di Creatività Infantile.

Beghetto, R. A., & Kaufman, J. C. (2007). Toward a broader conception of creativity: A case for "mini-c" creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *1*(2), 73. https://doi.org/10.1037/1931-3896.1.2.73

Bijvoet-van den Berg, S., & Hoicka, E. (2014). Individual differences and age-related changes in divergent thinking in toddlers and preschoolers. *Developmental Psychology*, *50*(6), 1629. https://doi.org/10.1037/a0036131

Chan, S., & Yuen, M. (2014). Personal and environmental factors affecting teachers' creativity-fostering practices in Hong Kong. *Thinking Skills and Creativity*, *12*, 69–77. https://doi.org/10.1016/j.tsc.2014.02.003

Cheung, R. H. P. (2012). Teaching for creativity: Examining the beliefs of early childhood teachers and their influence on teaching practices. *Australasian Journal of Early Childhood*, *37*(3), 43.

Cliff, N. (1993). Dominance statistics: Ordinal analyses to answer ordinal questions. *Psychological*

Bulletin, *114*(3), 494.

Craft, A., Cremin, T., Hay, P., Clack, J., Guilford, J. P., Ho, H. C., … Torrance, P. E. (1972). Creative Primary Schools : developing and maintaining pedagogy for creativity Creative Primary Schools : developing and maintaining pedagogy for creativity. *Creativity Research Journal*, *10*(1), 92–96. https://doi.org/10.1016/j.tsc.2013.04.003

De Bono, E. (1970). *Lateral thinking: Creativity step by step*. New York: Harper & Row.

De Bono, E. (1992). *Serious creativity: Using the power of lateral thinking to create new ideas* (Harper Col). London.

Entwistle, N., & Ramsden, P. (2015). *Understanding student learning (Routledge revivals)*. Routledge.

Ferrari, A., Cachia, R., & Punie, Y. (2009). Innovation and Creativity in Education and Training in the EU Member States: Fostering Creative Learning and Supporting Innovative Teaching. *JRC Technical Note*, *52374*, 64. https://doi.org/10.1007/978-94-6209-149-8_3

Gibbons, J. D., & Chakraborti, S. (2010). *Nonparametric statistical inference* (5th ed.). Boca Raton: Taylor & Francis/CRC Press. https://doi.org/10.1037/0033-2909.114.3.494

Gilberti, N., Corsano, P., & Antonietti, A. (2004). La rilevazione del pensiero creativo nei bambini in età prescolastica: un'analisi del Test di Creatività Infantile (TCI). *Psicologia Dell'Educazione e Della Formazione*, *6*, 357–372.

Gralewski, J., & Karwowski, M. (2012). Creativity and school grades: A case from Poland. *Thinking Skills and Creativity*, *7*(3), 198–208. https://doi.org/10.1016/j.tsc.2012.03.002

Grant, A. (2012). *Who Killed Creativity? And How Do We Get It Back?* (John Wiley & Sons, Ed.). Milton.

Guilford, J. P. (1957). Creative abilities in the arts. *Psychological Review*, *64*(2), 110–118.

Guilford, J. P. (1959). Three faces of intellect. *American Psychologist*, *14*(8), 469–479. https://doi.org/10.1037/h0046827

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International*

Journal of Science Education, *24*(4), 389–403. https://doi.org/10.1080/09500690110098912

Katz, S., & Stupel, M. (2015). Promoting creativity and self-efficacy of elementary students through a collaborative research task in mathematics: a case study. *Journal of Curriculum and Teaching*, *4*(1), 68. https://doi.org/10.5430/jct.v4n1p68

Kaufman, J. C., & Baer, J. (2006). Intelligent Testing With Torrance. *Creativity Research Journal*, *18*(1), 99–102. https://doi.org/10.1207/s15326934crj1801_11

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four c model of creativity. *Review of General Psychology*, *13*(1), 1. https://doi.org/10.1037/a0013688

Kim, K. H. E. E. (2011). Meta-Analyses of the Relationship of Creative Achievement to Both IQ and Divergent Thinking Test Scores. *The Journal of Creative Behavior*, *42*(2), 106–130. https://doi.org/10.1002/j.2162-6057.2008.tb01290.x

Kitto, J., Lok, D., & Rudowicz, E. (1994). Measuring Creative Thinking: An Activity-Based Approach. *Creativity Research Journal*, *7*(1), 59–69. https://doi.org/10.1080/10400419409534509

Lin, Y.-S. (2011). Fostering creativity through education. A conceptual framework of creative pedagogy. *Creative Education*, *2*(03), 149. https://doi.org/10.4236/ce.2011.23021

Lucas, B., Claxton, G., & Spencer, E. (2013). Progression in Student Creativity in School: First Steps Towards New Forms of Formative Assessments. *OECD Education Working Papers*, *86*(86), 45. https://doi.org/10.1787/5k4dp59msdwk-en

May, R. (2015). The Nature of Creativity. *Institute of General Semantics*, *16*(3), 261–276.

Moreland, R. L., & Myaskovsky, L. (2000). Exploring the Performance Benefits of Group Training: Transactive Memory or Improved Communication? *Organizational Behavior and Human Decision Processes*, *82*(1), 117–133. https://doi.org/https://doi.org/10.1006/obhd.2000.2891

Munari, B. (1977). *Fantasia. Invenzione, creatività e immaginazione nelle comunicazioni visive.* Bari: Laterza.

Rhodes, M. (1987). An analysis of creativity. In S. G. Isaksen (Ed.), *Frontiers of creativity research:*

Beyond the basics (pp. 216–222). Buffalo, NY: Bearly. Original work published 1961.

Rindermann, H., & Neubauer, A. C. (2004). Processing speed, intelligence, creativity, and school performance: Testing of causal hypotheses using structural equation models. *Intelligence*, *32*(6), 573–589. https://doi.org/10.1016/j.intell.2004.06.005

Robinson, K. (2011). Ch 1-3. *Out of Our Minds: Learning to Be Creative*, 1–44.

Robinson, K. (2015). *Creative Schools*. Penguin Books.

Rogers, C. (2012). On Becoming a Person: A Therapist's View of Psychotherapy.

Runco, M. A., Acar, S., & Cayirdag, N. (2017). A closer look at the creativity gap and why students are less creative at school than outside of school. *Thinking Skills and Creativity*, *24*, 242–249. https://doi.org/https://doi.org/10.1016/j.tsc.2017.04.003

Runco, M. A., & Jaeger, G. J. (2012). The Standard Definition of Creativity. *Creativity Research Journal*, *24*(1), 92–96. https://doi.org/10.1080/10400419.2012.650092

Runco, M. A., Millar, G., Acar, S., & Cramond, B. (2010). Torrance tests of creative thinking as predictors of personal and public achievement: A fifty-year follow-up. *Creativity Research Journal*, *22*(4), 361–368. https://doi.org/10.1080/10400419.2010.523393

Scott, G., Leritz, L. E., & Mumford, M. D. (2004). The effectiveness of creativity training : A quantitative review. *Creativity Research Journal*, *16*(4), 361–388.

Silvia, P. J., Winterstein, B. P., Willse, J. T., Barona, C. M., Cram, J. T., Hess, K. I., … Richard, C. A. (2008). Assessing creativity with divergent thinking tasks: Exploring the reliability and validity of new subjective scoring methods. *Psychology of Aesthetics, Creativity, and the Arts*, *2*(2), 68. https://doi.org/10.1037/1931-3896.2.2.68

Sternberg, R. J., Grigorenko, E. L., & Singer, J. L. (2004). *Creativity: From potential to realization.* American Psychological Association. https://doi.org/10.1037/10692-000

Torrance, P. E. (1974). *Torrance test of creative thinking: Norms-technical manual.* Princeton: Personnel Press / Ginn.

Tsai, K. C. (2013). Leadership recipes for promoting students' creativity. *International Journal of*

Humanities and Social Sciences, *3*(5), 1–9.

Vygotsky, S. L. (2004). Imagination and creativity in childhood. *Journal of Russian & East European Psychology*, *42*(1), 7–97.

Wallace, M. & Kogan, N. (1965). *Modes of thinking in young children*. New York: Holt, Rinehart and Winston.

Williams, F. E. (1993). Creativity Assessment Packet. *CAP. Pro-Ed*.

Wyse, D., & Ferrari, A. (2015). Creativity and education: Comparing the national curricula of the states of the European Union and the United Kingdom. *British Educational Research Journal*, *41*(1), 30–47. https://doi.org/10.1002/berj.3135

Zahra, P., Yusooff, F., & Hasim, M. S. (2013). Effectiveness of Training Creativity on Preschool Students. *Procedia - Social and Behavioral Sciences*, *102*(Ifee 2012), 643–647. https://doi.org/10.1016/j.sbspro.2013.10.782