Recreational mathematics in the development of creative thinking of Peruvian students of primary school

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Abstract: In traditional schools, the creativity tasks were related to art and literature. People rarely think mathematics provides a fundamental space for them. This research's objective is to determine the possible influence of the implementation of recreational mathematics on the development of creative thinking in university students. Through a quasi-experimental research, some modules of recreational mathematics were applied to a population of 125 students in the control group and experimental group. A random sampling was carried out, which allowed the constitution of a sample of 100 students that were proportionally divided into an experimental group and a control group. These were assessed through a creativity test. The results show that 66 % of the students increased their level of creativity in contrast to the low results of the control group. The use of recreational mathematics turned out to be an important tool to improve the creative thinking of the students.

Keywords: Recreational mathematics, fluency, originality, flexibility, creative thinking.

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1. Introduction

The essence of mathematics is thinking creatively, not only find the right answer (**Ayllón, Gómez &Ballesta-Claver 2016).** The current approaches in mathematics education promote the teaching of creative thinking to develop a deep conceptual understanding of mathematics (**Aizikovitsh-Udi& Amit 2011; Hadar&Tirosh 2019**). Since teaching creative thinking in mathematics is difficult and demanding, its implementation in curricular materials that are specifically designed for that purpose can help teachers and, at the same time, increase the probability of students' participation (**Araya, Giaconi&Martínez 2019**). As a central resource for teaching and learning, the curricular materials offer to the students the opportunity to participate with contents and skills (**Houang& Schmidt 2008**) and play a dominant role in learning, influencing what and how mathematics is taught (**Tarr et al., 2006; Fan, Zhu & Miao 2013**).

Many countries are implementing objectives of learning about creative thinking in their mathematics curriculums (**Gallagher, Hipkins& Zohar 2012**). In order to achieve their goals, teachers must consider the capacity of the curricular materials to stimulate and support creative thinking when they give assignments. They must understand those form the basis of the students' learning (**Doyle.1988; Williams.2002**). For example, in the activities given to the students, they routinely develop problem-solving procedures, but this is not creative thinking (**Hadar&Tirosh 2019)**. On the contrary, the activities that ask them to identify mathematical structures lead them to look for different and more creative opportunities (**Stein, Remillard, & Smith 2007; Stein & Kaufman 2010**).

2. Significance of the research

In the Peruvian curriculum, mathematics seeks to develop the capacity to act and think in different situations so they can interpret and act considering intuition, contemplating hypothetical cases, inferring, deducting, arguing, demonstrating, and improving communication and other skills as well as developing useful methods and attitudes to organize, quantify, and measure facts and quotidian phenomenon (**MINEDU, 2015**). That is the reason why the teacher of mathematics must use didactic teaching strategies that allow the development of these skills in the students.

That is why recreational mathematics is presented as a strategy based on social constructivism theories, where the kid is the main element of the learning process. Children have a fundamental participation in the construction of their learning and collaborative work by sharing their knowledge and constructing knowledge as a group as well as in the construction of multiple intelligences, where they watch, hear, and feel every teaching process, acquiring and developing each one of their skills.

Therefore, this methodology turns out to be propitious to reach the objectives and guidelines laid down by the Ministry of Education of Peru in order to achieve optimal results in the mathematics course. This research is important to demonstrate the influence of recreational mathematics on the learning of students of the third grade of primary school.

3. Review of related research

Aristizábal, Colorado & Gutiérrez (2016) developed a research that pursued to develop different skills and relationships to become familiar and reinforce the basic operations (addition, subtraction, multiplication, and division) in students of 5th grade, assuming that game occupies a fundamental place among children's activities. In this research, it was possible to determine that mathematical games encourage the students to improve the skills of logical thinking and work in the knowledge of procedures such as additions, subtractions, multiplications, and divisions. **Ozdogan (2011)** carried out a research that pursued to represent how the mathematical game gets involved in the education for children. The results obtained lead to the conclusion that, during the activities of mathematical games, students face different types of daily problems and create many solutions to them spontaneously. Therefore, mathematical games support logical thinking and create powerful learning environments. **Ginsburg (2006)** planted as an objective to describe the role of mathematics in the children's game and the role of the game in the education of mathematics. It was possible to establish that learning with mathematical games supports logical thinking and offers solutions to daily problems.

4. Objective

- This research pursued to determine the influence of the application of recreational mathematics as a strategy in the development of creative thinking in students from 4th to 6th grade of the primary school of a public educational institution in the city of Huanuco, province and department of Huanuco, Peru.

5. Hypotheses

- Null Hypothesis (Ho): The application of recreational mathematics does not influence directly the development of creative thinking of students from 4th grade to 6th grade of primary school in the city of Huanuco, Peru.
- Alternative Hypothesis (H1): The application of recreational mathematics influence directly on the development of creative thinking of students from 4th grade to 6th grade of primary school in the city of Huanuco, Peru.

6. Population and sample

The population of the study was composed of 125 students enrolled between 4th and 6th grade of primary school in a public educational institution, which is located in the city of Huanuco, province and department of Huanuco, Peru. Two groups were composed for the research: the experimental group and the control group. Then, a random sampling was carried out, which allowed the constitution of a sample of 100 students that were proportionally divided into two groups: experimental and control.

6.1. Statistical techniques

In order to collect data on the development of creative skills, a module of teaching recreational mathematics divided into 7 workshops was applied to the students of the experimental group. Those workshops were prepared following the indicators of creativity that were considered in this research: Originality, fluency, and flexibility. These workshops were applied at the same time classes of basic mathematics were given as usual. On the other hand, the group control did not receive those workshops. A pretest and a posttest were applied to both groups; both tests had 20 questions that were prepared according to the indicators: originality (8 questions), fluency (6 questions), and flexibility (6 questions). The instrument was validated through expert judgment and a pilot test was carried out to measure reliability.

The results of the pre- and post-test were organized according to the levels of the rating scale of creativity (CAP) (Williams, 1993), as shown in Table 1.

Table 1. Creativity level according to the CAP rating scale

Qualitative scale	Quantitative scale
Medium-low	00 – 05
Medium	06 – 10
Medium-high	11 – 15
Creative	16 – 20

Source: Williams (1993: 27)

Data obtained was analyzed through a descriptive and inferential statistic. Data was tabulated according to the experimental group and control group, with the respective pre- and post-test according to a table of frequencies and percentages. Likewise, the hypotheses planted were corroborated with a reliability of 95 % and a level of significance of 0.05. The normality of the sampling distribution was tested through a Z-test:

$$Z_{calc} = \frac{\underline{X_1} - \underline{X_2}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

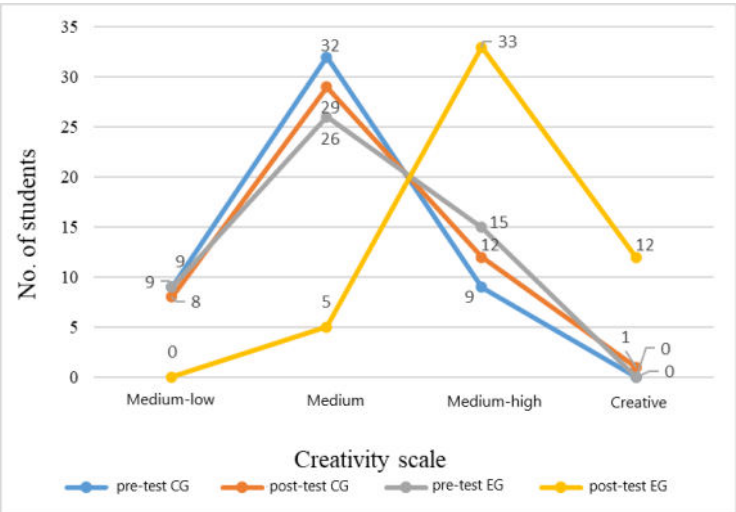
Where:
$\bar{X}_1$: Experimental group mean with respect to the post-test
$\bar{X}_2$: Control group mean with respect to the post-test
S_1^2: Experimental group deviation with respect to the post-test
S_2^2: Control group deviation with respect to the post-test

The critical value Z_{cri} was obtained through the table; so, if $Z_{calc} > Z_{cri}$, the null hypothesis is rejected and the alternative hypothesis is accepted.

6.2. Data analysis and interpretation

6.2.1. Comparison between pre- and post-test of control group and experimental group

Figure.1 Comparison between pre- and post-test of the control group (CG) and the experimental group (EG) according to the creativity scale.



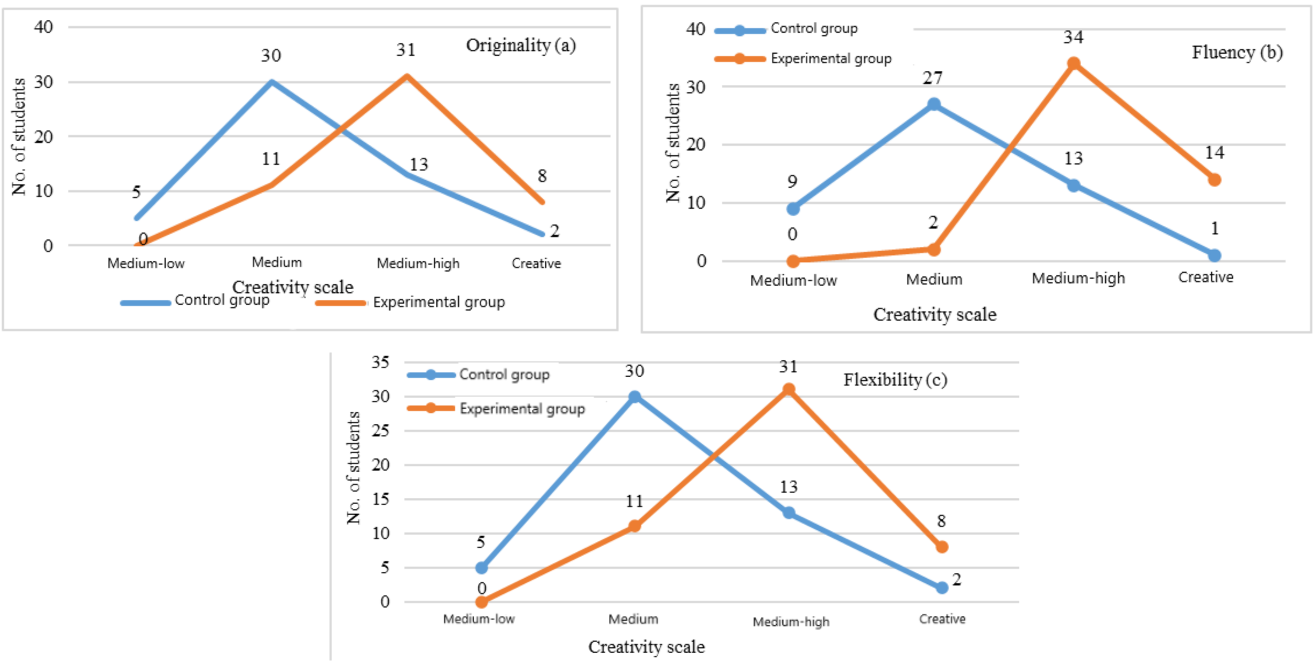
Interpretation of Figure 1.

Figure 1 shows the global results of pre- and post-test of the control group (CG) and the experimental group (EG). After the comparison between the pre- and post-test of the control group, it is possible to establish that only18 % of students have a high level of creativity in the pre-test. After the post-test, that percentage increased to 42 %, which represents an increase of 24 %. When the pre-test was applied to the control group, no student was at the level "creative". After the post-test, only 1 student reached that level, which means that levels of creativity did not increase in important values through the traditional teaching. After the post-test was applied to the control group, it was possible to evince that 74 % of students stayed at the level "low" and "medium" in the creativity scale. If this value is compared with the pre-test, when 82 % of students were at the level "low" and "medium", which represents a decrease of 8 %. In other words, only 4 students could go through the level "low" and "medium" to the level "high" of creativity.

When the instruments of recreational mathematics were applied to the experimental group (EG), as shown in Figure 1, it was possible to evince the following aspects: when the diagnostic was applied through the pre-test, it was detected that 70 % of the students were at the levels "low" and "medium" in the creativity scale; once the instrument was applied, it was determined through the post-test that only 10 % of the students were at the level "medium" of the creativity scale and no student was at the level "low". In average terms, it was detected that 29 students went through "low" and "medium" to the level "high", which evinces the importance of the application of recreational mathematics on the development of creative skills of students. The results at levels "high" and "creative" in the experimental group show that only 1 student (in the pre-test) was at the level "creative". After the application of the post-test, 12 students were at the level "creative". In general terms, the pre-test applied to the experimental group evinced that 30 % of the students were at the level "high" in the creativity scale. After the application of the post-test, that percentage increased to 66 % of students, which represents an increase of 36 % and a general increase of 60 % of the students that reached the levels "high" and "creative. That evinces the impact of recreational mathematics on the participants.

6.2.2. Comparison of the post-test according to the indicators of creativity.

Figure.2 Results of the post-test of the control group and the experimental group according to the indicators: (a) Originality, (b) Fluency, and (c) Flexibility.

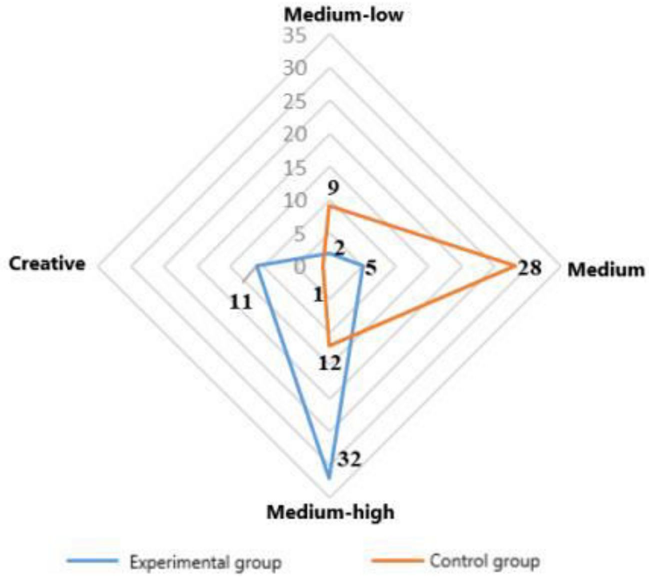


Interpretation of Figure 2.

According to the values shown in Table 2, those represent the number of studentsvs the creativity scale grouped by levels for the indicators (originality, fluency, and flexibility). The post-test results were compared for the control group (CG) and the experimental group (EG). Regarding the indicator "originality" (Figure 2), in the control group, only 4 % (2 students) reached the level "creative", whereas 60 % of students were at the level "medium". On the other hand, in the experimental group, 62 % of the students reached the level "high" in the creativity scale and 16 % of them reached the level "creative". Figure 2 shows the results related to the indicator "fluency", where 72 % of the students of the control group were at the levels "low" and "medium" in the creativity scale after the post-test. In the experimental group, 96 % of the students reached the levels "high" and "creative" in the post-test. In the indicator "flexibility" (Figure 2c), 30 % of the students of the control group reached the levels "high" and "creative", in contrast with the experimental group where 78 % of the students reached the same level after the post-test.

6.2.3. Comparison of the post-test according to the indicators of creativity

Figure.3 Comparison of the post-test between the experimental group and control group



Interpretation of Figure 3.

Figure 3 shows the comparison between the experimental group and control group regarding the post-tests averaged results of the creative skill indicators. In general terms, it was evinced that after the application of the instrument and post-test, 64 % of the students of the experimental group reached the level "high" in the creativity scale. On the other hand, only 24 % of the control group reached that level. Regarding the maximum level in the creativity scale "creative", 22 % of the students of the experimental group reached that level. On the other hand, only 1 % of the control group reached the aforementioned level.

In general terms, 86 % of the students (43 students) of the experimental group were at the levels "high" and "creative", whereas the percentage was 26 % in the control group. That indicates that, compared with the pre-test (see Figure 1), from 35 students of the experimental group that were at the levels "low" and "medium", only 5 students were left behind at level "medium" after the application of recreational mathematics tools. In other words, from 35 students that were at regular levels of creativity, 30 students passed to the levels "high" and "creative". That indicates the level of impact of the application of recreational mathematics as a tool for the development of creative thinking. Regarding the control group, only 4 students went from regular levels of creativity to the level "high". On average (see Figure 3), after the application of the post-test, the majority of the students of the control group (56 %) were at the level "medium" of creativity, whereas the majority of the students of the experimental group (64 %) were at the level "high" in the creativity scale.

6.2.4. Hypothesis test

Table 1. Statistic for the analysis of the development of creative thinking of the control group and experimental group.

Measure	Pre-test		Post-test	
	Experimental group	Control group	Experimental group	Control group
Mean	8.42	8.66	14.10	9.06
Median	8.00	9.00	14.00	9.00
Mode	8.00	9.00	15.00	10.00
Standard deviation	1.63	1.66	1.31	1.61
Sample variance	2.66	2.76	1.72	2.58
Skewness coefficient	0.05	-0.03	-0.08	-0.32
Range	7.00	5.00	6.00	6.00
Minimum	5.00	6.00	11.00	6.00

Maximum	12.00	11.00	17.00	12.00
Units of analysis	50	50	50	50

Interpretation of Table 1.

Through the data obtained from the descriptive statistic shown in Table 2, the hypotheses suggested to determine the influence of recreational mathematics on the development of creative thinking were corroborated.

A Z-test was carried out since thesampling distribution of differences between means was approximately normal. It was assumed a 95 % of reliability for a level α of significance of 5 %, so the critical value Z_cri obtained was 1.96. The value calculated Z_calc with the values shown in Table 1, using the equation (1), was 17.2, so it is placed to the right of the critical value, which is the region of rejection. Therefore, the hypothesis null is rejected and the alternative hypothesis is accepted, which means the application of recreational mathematics significantly influences the development of creative thinking of the students from the 4th to 6th grade of primary. Consequently, what was suggested in the general hypothesis is proved.

It was evinced that the application of recreational mathematics as a strategy has an optimal level of efficacy on the development of creative thinking in students from 4th to 6th grade of primary. In this context, the use of active methodology was valued, which was considered in the programming and development of learning activities, particularly in the experimental group. Likewise, it was necessary to emphasize the basis of recreational mathematics, creative thinking, and game theory (Fernández& Rodríguez, 1989; Vera, 2008; Cofre& Tapia, 2007). With the application of recreational mathematics, it was possible to develop creative thinking as regards its originality, fluency, and flexibility. In such a way that work within the constructivist approach allowed the students to develop conceptual, procedural, and attitudinal skills to interact effectively and efficiently in their context.

The result of the mathematical creative thinking of students achieved through the instrument applied is relevant for the opinions of Guilford, (1968); Oslon, (1980); Torrance, (1965), regarding that creative thinking is the skill to see different possibilities to solve a problem considering fluency, flexibility, and originality. In the research of Saefudin (2012), it was possible to find that the implementation of the approach of realistic mathematics education can develop skills of creative thinking. The reinvention guided allows the students to rediscover the mathematical concept. The mathematical model in problem-solving allows the students to develop their skills of creative thinking. The fluency in problem-solving is based on the students' skill to solve problems by giving a variety of right answers. Some of the right answers are different and do not have a pattern of strict rules, called flexibility. The novelty in problem-solving is based on new and unique answers of the student. Similarly, Osborn (1953) affirmed that someone could not solve the problems found before understand them. If someone understands the problem, the next stage of a process of creative thinking is getting ready for problem-solving: incubation, illumination, and verification.

Students communicated with their classmates to discuss and proving alternative answers. This finding is relevant to the opinion of Duncker&Krechevsky, (1939), who affirmed that discussing with classmates to find creative solutions is one of the processes of preparation. If students are given mathematical problems (open questions), they try to solve them using their own approach by remembering and recycling ideas of their experiences and previous knowledge they acquire in their previous class. However, both knowledge and experience are not enough to broach problems of mathematical creativity, so it is unlikely that creative ideas emerge.

The student's development of creative ideas is a process of mathematical activity. That coincides with the opinion of Riedesel, Schwartz & Clements, (1996) that mathematics is an activity. Doing mathematics is not only focused on the final solution, but the process such as finding patterns and the relationship, conjecture tests, and result estimations. It is necessary that someone uses and adapts the knowledge acquired in the process of creation of a new understanding. Besides the activities developed in mathematics, the process of development of new knowledge may start from the activities external to mathematics to solve the contextual problems. This process may improve the capacity of the student's adaptative reasoning, particularly, in the overcoming of problems external to mathematics that can be mathematically solved.

7. Recommendations

Teachers are recommended to implement the contents of recreational mathematics in their programs since its application allows the students to develop creative thinking. The easiness of recreational mathematics does not only cover it with the fantasy but also with fun, without breaking the preciseness of the mathematical process.

8. Conclusion

Through this research, it is demonstrated that the application of recreational mathematics significantly influences the development of the students' creative thinking. After the data processing, it is possible to demonstrate that the majority of the units of analysis of the experimental group reached the levels "high" and "creative". The control group did not present significant progress, so they stayed in the level "medium". Ministries of Education are recommended to implement in their curriculums and promote training related to the strategies of mathematics teaching through mathematical games, recreational problems, and mathematical paradoxes, which are situations that allow the development of logical-mathematical thinking and creative thinking.

The mechanism of valuation and promotion of innovation as part of education is the gap discovered in the research, which allows to give the students the tools to discover new ways to generate and give knowledge. The implementation of all the resources available is what makes recreational mathematics so attractive. In order to generate successful learning processes, it is necessary to include programs in the educational process that promote creativity. With the special support of the new technologies available that are mostly friendly with platforms of easy access, all of them of easy adaptation to the educational field.

References

Cofre, A. & Tapia, L. (2007). *Matemática Recreativa en el Aula*. México: Alfaomega.

Doyle, W. (1988). Work in mathematics classes: The context of students' thinking during instruction. Educational *Psychologist*, 23(2), 167–180. https://doi.org/10.1207/s15326985ep2302_6

Duncker, K., &Krechevsky, I. (1939). On solution achievement. Psychological Review, 46, 176–185. Recuperado de: https://psycnet.apa.org/record/1939-02967-001

Fan, L., Zhu, Y. &Miao, Z. (2013). Textbook research in mathematics education: Development status and directions. *ZDM Mathematics Education*, 45(5), 633–646. https://doi.org/10.1007/s11858-013-0539-x

Fernández, J. & Rodríguez, M (1989). *Juegos y Pasatiempos para la Enseñanza de la Matemática Elemental*. España: Editorial Síntesis S.A.

Gallagher, C., Hipkins, R. &Zohar, A. (2012). Positioning thinking within national curriculum and assessment systems: Perspectives from Israel, New Zealand and Northern Ireland. *Thinking Skills and Creativity*, 7(2), 134–143. https://doi.org/10.1016/j.tsc.2012.04.005

Ginsburg, H. P. (2006). Mathematical Play and Playful Mathematic: A Guide for Early Education. In G. D. Singer, R. M. Golinkoff, & K. Hirsh-Pasek, *Play=Learning, How many* (pp. 145-165). New York: Oxford University Press.

Guilford, J. P. (1968). *Creativity, intelligence, and their educational implications*. San Diego: CA: EDITS/Robert Knapp.

Hadar, L. &Tirosh, M. (2019). Creative thinking in mathematics curriculum: An analytic framework. *Thinking Skills and Creativity*, 33. https://doi.org/10.1016/j.tsc.2019.100585

Houang, R. T., & Schmidt, W. H. (2008). TIMSS international curriculum analysis and measuring educational opportunities. En C. Papanastasiou (Ed.), *3rd IEA International Research Conference* (pp. 1-14). Amsterdam, Holanda: IEA

Osborn, A. (1953). *Applied imagination*. New York: Charles Scribner.

Oslon, R. W. (1980). *The art of creative thinking*. New York: Bames& Noble Books.

Riedesel, C., Schwartz, J., & Clements, D. (1996). *Teaching elementary school mathematics*. Boston: Allyn and Bacon.

Saefudin, A. (2012). Development of students' creative thinking skills in learning mathematics with the Indonesian realistic mathematics education approach (PMRI). *Al-Bidayah,* 4(1). Recuperado de: https://jurnal.albidayah.id/index.php/home/article/download/10/8

Stein, M., Remillard, J. & Smith, M. (2007). How curriculum influences student learning. In F. Lester (Ed.). *Second handbook of research on mathematics teaching and learning* (pp. 319–370). Charlotte, NC: Information Age Publishing.

Stein, M., Smith, M., Henningsen, M. & Silver, E. (2010*). Implementing standards-based math instruction: A casebook for professional development*. NY: Teachers College Press.

Tarr, J., Chávez, O., Reys, R. &Reys, B. (2006). From the written to the enacted curricula: The intermediary role of middle school mathematics teachers in shaping students' opportunity to learn. *School Science and Mathematics*, 106(4), 191–201. https://doi.org/10.1111/j.1949-8594.2006.tb18075.x

Torrance, E. (1965*). The nature of creativity as manifest in its testing*. NY: Cambridge UniversityPress.

Vera, H. (2008). *Super Acertijos Recreativos*. Perú: Editorial San Marcos.

Williams, F. (1993). *Paquete de Valoración de la Creatividad*. Texas: PRO-ED.

Williams, G. (2002). Identifying tasks that promote creative thinking in mathematics: A tool. *Mathematics Education in the South Pacific*, 2, 698–705. Recuperado de: https://www.researchgate.net/publication/228689947_Identifying_tasks_that_promote_creative_thinking_in_mathematics_a_tool