Logical-mathematical thinking in teachers of secondary education: an ethnomathematical perspective

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Abstract: The objective of the research was to identify the relationship between the development of logical-mathematical thinking and ethnomathematics as pedagogical resources in teachers of secondary. A research with a quantitative approach, quasi-experimental design, and explicative level was carried out. Also, a non-probability sampling was carried out to choose 60 teachers of secondary of two educational institutions of the city of Lima, Peru. A methodology with pre and post-test was applied to an experimental group and control groups, using a test of mathematical skills as an instrument of data collection. The experimental group was intervened through the application of six topics related to the fundamental mathematical operations under an ethnomathematical approach. The results were analyzed through a descriptive statistic and a variance analysis, with a reliability level of 95 %. The intervention, carried out under the ethnomathematical approach, influences the increase of skills of logical-mathematical thinking in a significant way in comparison with the level shown at the beginning of the research.

Keywords: Ethnomathematics, logical thinking, mathematics skill, pedagogical resource, secondary education

1. Introduction

Teaching mathematics to a group of students with the same mathematical skills, the same learning styles, and the same cultural background would probably be easy; however, this is not the reality of the classroom. The students in the classrooms might have different experiences of life, cultural background, and learning styles. Regarding that, it is possible to indicate that cultural realities of each school jurisdiction must classify the necessities of their students; however, it does not happen in reality since the same curriculum is given in the whole country, which is established to satisfy general necessities. Cultural differences must be considered for the teaching of any subject.

Currently, the proposal of ethnomathematics is on a discussion with respect to the topic of valuing the cultural and social differences in the school environment. Also, there is a strong reaction to the existence of a common curriculum and the way imposed of presenting a unique view of mathematics as universal knowledge of the absolute truths **(Fonseca & Ferreira, 2015)**. Moreover, the deficiencies with respect to the mathematical reasoning of the secondary students that were evinced in 2018 by the results of the Programme for International Student Assessment (PISA) presented by the Ministry of Education of Peru, which is closely related to teachers' knowledge. These results establish that students lack the skills that allow them to have logical-mathematical thinking, which is able to solve difficult situations, as well as skills and abilities to face new situations. This expressed the unfulfillment of one of the main objectives of teaching mathematics, which is the development of logical, flexible, and creative thinking in the students **(Nieves et al., 2019).** That involves the strategies applied by teachers and the curriculum given.

On the other hand, **Leiva (2016)** expresses that part of the results that students show depend, among other factors, on the strategies that teachers use to give significant teaching. Based on that, when students get to the 3rd year of secondary already were taught by different teachers of mathematics, which is why their lack of knowledge and skills for this subject is the result of the deficiencies in teachers' training.

According to **Vilchez (2018),** teaching mathematics with technological resources, through the relationship of the students with their social, cultural, and physical environment, generates a balanced and appropriateeducational process. That reinforces the students' numerical, algebraic, and geometric thinking, which leads them to improve their mathematical skills. At the same time, that motives the students to broach other mathematical topics through didactic resources that come from ethnomathematics.

Based on the problem presented and the aforementioned affirmations, the objective of this research was to identify the existing relationship between the development of logical-mathematical thinking and ethnomathematics as a pedagogical resource in teachers of secondary education.

2. Theoretical reflection and background

2.1. Ethnomathematics

Part of the academic training of students is based on the learning of mathematics, which contributes to the development of their skills of logical reasoning and oral expression as well as the continuous development demonstrated in their ways of expression that are obtained after the coding of information of the environment and behaving according to that **(Rico, 1998)**. Considering all the challenges that society faces every day, teachers of mathematics face heterogeneity and multiculturalism of the students in different educational levels. It generates that the pedagogical strategies of teaching are adapted to the system, including mathematics **(Vilchez, 2018)**.

This adaptation of teachings strategies was presented in 1980 by the mathematician and university professor UbiratanD'Ambrosio, under the name of ethnomathematics. On that occasion, he proposed a research program aimed at valuing the knowledge created by specific groups and recognizing creative ways of knowledge that sometimes come up informally among some groups that look for solutions to their own problems **(D'Ambrosio, 1998)**. The first time that D'Ambrosio used the word "ethnomathematics" was to explain the mathematical manifestations of different ethnic groups and cultures. He defined it like this: Ethnomathematics is "ethno" + "mathema" + "tics": their natural and cultural environment (ethno); explaining, teaching, understanding, handling, dealing (mathema); arts, techniques, ways, styles (thics). This is the mathematics practiced among cultural groups identifiable as national, tribal, working class, children of some age, professional class, and other societies. **(D'Ambrosio, 1998, p.49)**.

Regarding the ideas of D'Ambrosio, in this research, ethnomathematics is considered as a group of techniques or strategies to learn and/or teach mathematics, considering the cultural idiosyncrasies of the natural, social, and cultural environment as the basis.

In this sense, ethnomathematics represents a methodology for the research and continuous analysis of the processes that transmit, spread, and become the mathematical knowledge institutionalized. Those processes originated from different cultural contexts in history. This context caused the appearance of six dimensions of the ethnomathematical approach: cognitive, conceptual, educational, epistemological, historical, and political **(Rosa &Orey, 2016).** Those dimensions lead to the development of innovative approaches to establish a dynamic society **(Rosa et al., 2017)**.

The research of ethnomathematics is traditionally focused on three principal areas: theoretical and philosophical, analysis of comprehensive mathematical activities in specific practices of different cultural groups, and applications of ethnomathematics in education **(Shirley, 2008)**. In this environment, the ethnomathematical approach is an integration of concepts and practices that originate in the culture of students with formal academical mathematics **(Mohr-Schroeder et al., 2015)**. Based on this definition, ethnomathematical learning is the process where the students bring mathematical experiences of their own culture and other cultures to understand how mathematical ideas are formulated and applied **(Rosa & Shirley, 2016)**.

According to **Sachs & Santos (2018),** it is possible to highlight two ways to perform the pedagogical work based on ethnomathematics. The first one uses this as starting point to reach the systematized knowledge in the school curricula, whereas the second one consists in incorporating other knowledge in school curricula by making a dialogue between knowledge.

Different authors researched to analyze the ideas of teachers that receive strategies such as workshops, from the ethnomathematical perspective (**Albanese & Perales, 2020; Albanese & Perales, 2017**). The results establish that teachers learn new techniques of teaching-learning of mathematics that allow them, in addition, to improve as cultural and historically placed people **(Micalco&Villaseñor, 2017)**. **Gavarrete (2013)** indicates that executing the strategy of workshops allows teachers to obtain tools that will help them to identify, in the environment, different cultural traits with mathematical content, which they took to give classes. In other words, it helps them in their training to establish new content. Likewise, **Rosa et al., (2017)** expressed that the techniques acquired in the ethnomathematics approach are related to pedagogical aspects and support teachers in their teaching processes. Regarding that, **Blanco et al., (2017)** determined that part of the success of the subjects with the approach of ethnomathematics depend on the characteristics of teachers in terms of their creativity and an open mind to develop new teaching methodologies.

The level of analysis regarding the approach of ethnomathematics applied to the teaching of mathematics is such that a review in Central America and North America revealed that, in different countries of these regions, there are significant contributions to the development of the Ethnomathematics Program **(Yojcom et al., 2016)**.

2.2. Logical-mathematical thinking

The purpose is that students develop logical-mathematical thinking based on ethnomathematics. Regarding that, **Petrovski (1985)** expressed that thinking is generated from an object. Then, it is possible to obtain a thinking: logical and scientific, figurative and practical. The first one follows the laws of logic. When it is developed in the field of mathematics, we talk about logical-mathematical thinking.

On the other hand, **Parada&Pluvinage (2014)** expressed that the teacher's participation is fundamental for the students to develop logical-mathematical thinking that allows them to find different ways to represent the contents through examples, demonstrations, comparisons, images, and explanations.

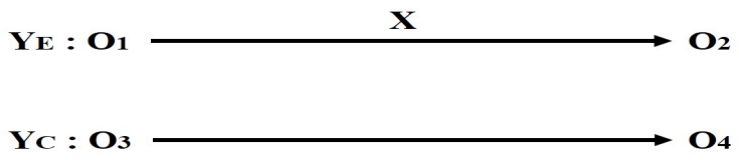
Herlina (2015) defines the logical-mathematical thinking as "the cognitive process that understands the representation, abstraction, creativity, and mathematical demonstration" (p.2). This requires the teachers' support in the teaching-learning process, which is why preparing teachers from an ethnomathematical perspective would be convenient in order to achieve the logical-mathematic thinking that, at the same time, allows the students to develop this kind of thinking.

Many studies have diagnosed the deficiencies in the logical-mathematical analysis of the students. That is how **Vilca (2018)** exposed that the students reach a high level of logical-mathematical reasoning when the teaching methods applied motivate them to think using different techniques. In this way, they increase their level of understanding and acquisition of fundamental skills to solve complex numerical situations. Moreover, **Leiva (2016)** adds that the acquisition of mathematical skills in students is necessary to solve specific complex situations, which improves their logical-mathematical reasoning at the same time. Also, Leiva indicated that thinking is the one required to answer the PISA assessment. In addition to these affirmations, **Medina (2018)** determined that students must necessarily have skills that help them to reason in different situations. That would depend on the methodology applied to achieve it, which is why teachers and their strategies are a key element.

3. Methodology

The research was quantitative, with a quasi-experimental design and explicative level. The sample consists of 60 teachers of secondary of the educational institutions "Carlos Rengifo" and "José Martí", which are located in the city of Tacna, south of Peru. It was a non-probability sample and convenience sample, establishing as choice criteria: six teachers of each grade who agreed to be part of the study. It had a pre-test and post-test quasi-experimental design, with a control group (teachers of EI José Martí) that stayed intact and an experimental group (teachers of EI Carlos Rengifo). The last one was intervened through the application of six topics related to fundamental operations such as natural, whole, and rational numbers as well as algebra (Figure 1) to measure the level of logical-mathematical thinking. The intervention programs were adapted to the natural, cultural, and social environments according to the principles of ethnomathematics.

Figure 1. Diagram of the quasi-experimental design suggested.



Where:
YE = Experimental Group.
YC = Control Group.
O1 = Application of the initial test (pre-test) to the experimental group.
O3 = Application of the initial test (pre-test) to the control group.
O2 = Application of the final test (post-test) to the experimental group.
O4 = Application of the final test (post-test) to the control group.
X = Intervention in the experimental group.

In order to measure the effect of the intervention on the experimental group, a diagnostic test instrument was developed. This instrument was composed of specific questions related to the fundamental mathematical operations and was initially applied to both groups (pre-test) to measure the initial level of teachers with respect to logical-mathematical thinking, with a scale from 0 to 20 points, and value it as shown in Table 1.

Table 1. Rating scale of the score obtained in the instrument applied

Score range	Appreciation
6 – 8	Beginning
9 – 11	In process
12 – 14	Intermediate
15 – 17	Enough
18 – 20	Excellent

After the intervention to the experimental group from the perspective of ethnomathematics, a test was applied to both groups again. It was different from the initial one but also with questions related to the logical-mathematical operations (post-test). The results were evaluated according to the scale used in Table 1.

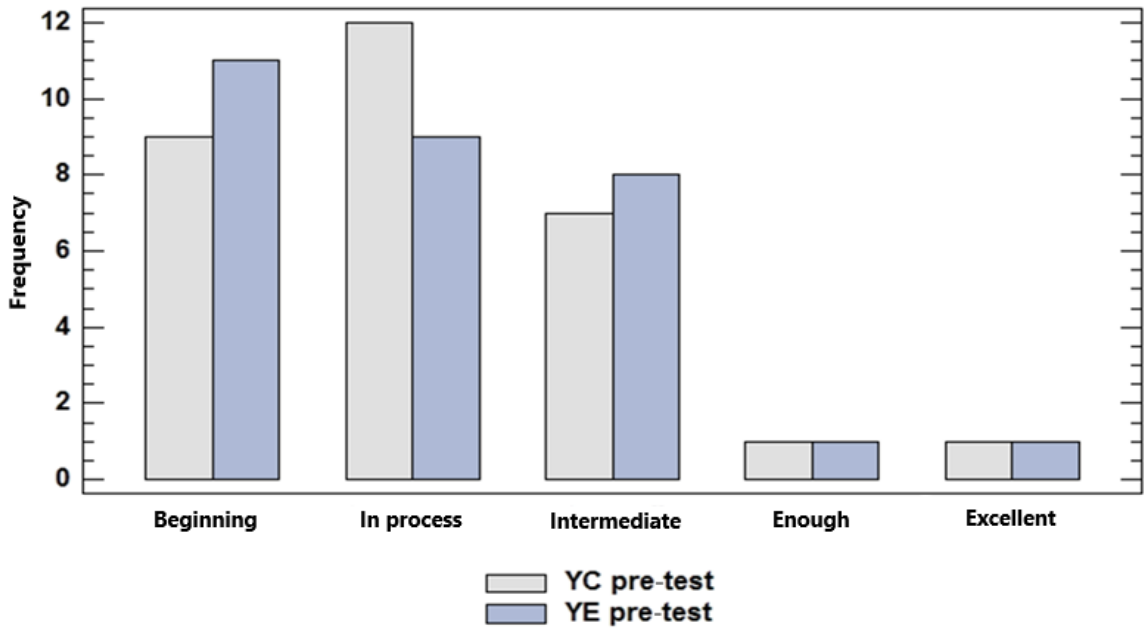
In order to establish the effect of the intervention applied to the teacher's logical-mathematical thinking, the assumptions of normality of the groups' scores were analyzed through the Shapiro-Wilk test. That test is recommended for samples less than 50 (Romero, 2016), with the objective to determine whether the comparison between groups would be made with a parametric or non-parametric statistic. In case of normal behavior of the data, the analysis of variance (ANOVA) will be applied to establish the comparison between groups. If the assumption of normality is not true, the median equality analysis or Mann-Whitney W test. All the statistical analyses were made with the Statgraphics Centurion XVII statistical package, with a significance level $\alpha = 0.05$ (95% of reliability level).

4. Results

4.1. Analysis of the pre-test application results

After the application of the pre-test to both groups (Y_E and Y_C) and the classification of frequencies by categories, the result shown in Figure 2 was obtained.

Figure 2. Distribution of frequencies by categories in the pre-test



Regarding the control group, it is possible to see that the majority of teachers have competencies of logical-mathematical thinking at the level“in process” (12), whereas a group of teachers presents their competencies at the level “beginning” (9). In the case of the experimental group, the majority of teachers present competencies of logical-mathematical thinking at the level “beginning” (11), whereas other teachers are at the level “in process” (9). In percentage terms, in both groups, the competencies were mostly distributed among the categories “beginning” and “intermediate” with 93.33 %, whereas only 6.67 % of both groups were in the categories “enough” and “excellent”. Initially, it is demonstrated that both groups are homogeneous with respect to their knowledge of mathematics, with a deficient performance.

Table 2 shows the results obtained after the analysis of the assumption of normality of the pre-test data through the Shapiro-Wilk normality test, with a statistical reliability level of 95 %.

Table 2. Results of the Shapiro-Wilk normality test of the pre-test

Group	Shapiro-Wilk test	p-value
Y_C	0.93	0.0807
Y_E	0.93	0.0647

In both cases, it is possible to see that p-valor > 0.05; so, the normality test indicates that it is impossible to reject the assumption that data come from a normal distribution (Rigalli et al., 2019). The aforementioned information indicates that, in order to compare both groups, it is possible to use the parametric variance analysis (ANOVA) based on the comparison of means. However, due to the proximity of the p-value to the significance, a non-parametric comparison of Mann-Whitney U, based on the median to corroborate the comparison with two statistics, was carried out. Table 3 shows the results of the comparison tests between the groups according to the pre-test.

Table 3. Results of the comparison between the results of the pre-test of the groups under study.

Test	Groups	Measure of central tendency	p-value
ANOVA	Y_C	10.37	0.8069
	Y_E	10.17	
Mann-Whitney	Y_C	10.00	0.7945
	Y_E	10.00	

Both tests are based on the hypothesis that there is no significant difference between the measures of central tendency, for which p-valor > 0.05 (reliability level of 95%). As observed, the condition is met for both tests with similar p-value results. That demonstrates that, at the beginning of the research, both groups of study do not present significant differences with respect to the competencies of logical-mathematical thinking.

4.2. Analysis of the post-test application result

After the intervention in the experimental group, the assessment of competencies of logical-mathematical thinking was applied to both groups again. Figure 3 shows graphically the results.

Figure 3. Distribution of frequencies by categories in the post-test

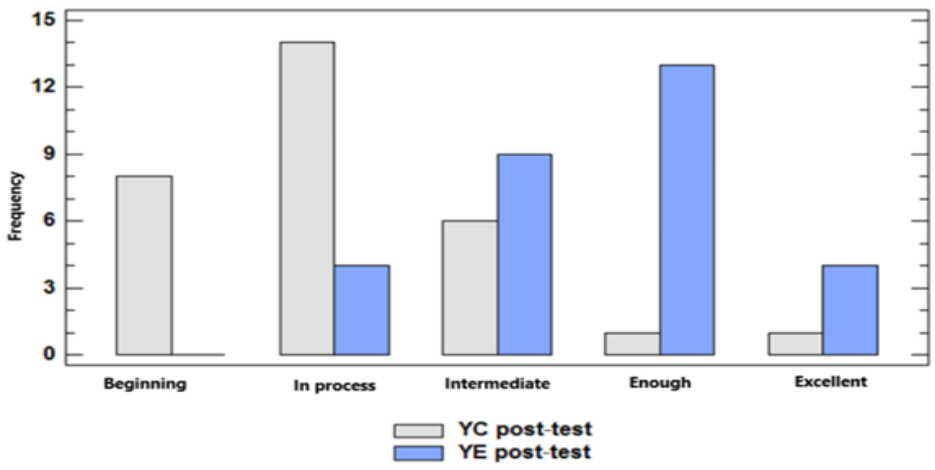


Figure 3 shows that both groups demonstrated different tendencies with respect to the scores of the post-test. The control group maintained a similar behavior to the one showed in the pre-test, with 14 teachers with knowledge of logical-mathematical thinking at the level "in process", 8 at "beginning", and 6 at "intermediate". That represents 93.33 % of the total as well as in the pre-test. On the contrary, the experimental group presented a tendency to the highest scores, with 13 teachers at the level "enough", 9 at "intermediate", and 4 at "excellent". That represents 86.67 % of them, whereas the other 13.33 % were at the level "in process".

Table 4 shows the results obtained after the analysis of the assumption of normality of the post-test data through the Shapiro-Wilk normality test, with a statistical reliability level of 95 %.

Table 4. Results of the Shapiro-Wilk normality test of the post-test

Group	Shapiro-Wilk test	p-value
Y_C	0.93	0.0775
Y_E	0.97	0.5712

Like the observed for the pre-test, the normality test of Shapiro-Wilk showed that the post-test results correspond to a normal distribution in both groups (p-value > 0.05). However, it is observed that the normal behavior in the experimental group is more noticeable, so it is possible to affirm that 57 % of the values correspond to the normal distribution. In contrast to the control group, which shows a behavior less corresponding to the normality, with a p-value closer to the significance. In this particular case, only a parametric comparison through the variance analysis ANOVA was applied. Table 5 shows the results.

Table 5. Results of the comparison between the pre-test results of the groups under study.

Test	Groups	Measure of central tendency	p-value
ANOVA	Y_C	10.33	0.0000
	Y_E	14.94	

In this case, it is observed that the hypothesis of means equality is met since p-value < 0.05. That demonstrates there is a difference between the means of both groups, where the experimental group shows the highest value. Therefore, it is possible to say that the intervention with ethnomathematics caused a positive and statistically significant change in the competencies of logical-mathematical thinking of teachers that received it, in comparison with those who were not subject to the intervention. Likewise, after the comparison between the pre-test and post-test in each group, there was no significant difference in the control group (p-value = 0.9654), which means this group maintained its performance without intervention. On the contrary, a p-value of 0.0000 was obtained in the experimental group, which demonstrates that the intervention caused a significant difference in the teachers' competencies that was positive since the scores obtained improved in the post-test.

5. Discussion

The results of the diagnostic test indicated that teachers have a low level of logical-mathematical thinking regardless of the group they belong to. This is a factor that might negatively influence teaching, not only of mathematics but of other sciences that depend on it. The aforementioned information agrees with Medina (2018), who considers that difficulties that students present in mathematics are due to the lack of application of strategies that motivate them and the use of a general methodology that is no of their interest. Likewise, Bermúdez (2018) suggests that logical reasoning is fundamental for learning mathematics. Also, the above-mentioned author suggests that the active participation of students must be promoted, especially in the relationship between mathematics and the environment, achieving their association with the aspects of daily life so that they are seen in a less complex way. That is why the role of teachers and their logical knowledge are fundamental in this process.

Likewise, Castrillón&Ramírez (2016) agree to consider that teachers' little knowledge of the application of didactic strategies to teach makes the students have a low level of logical-mathematical thinking, which influences the learning of all subjects. The aforementioned information supports the appreciation that the low level of logical-mathematical thinking showed by teachers subjects to study is a factor that can influence negatively the students' skills and abilities for their learning. For that reason, the use of strategies based on ethnomathematics is fundamental to improve, not only the teachers' knowledge but the students' too.

After the intervention in the experimental group from the ethnomathematics perspective, it was possible to observe that the tendency in the grades obtained with respect to the logical-mathematical thinking change in that

group, in comparison with the control group that maintained a tendency very similar to the one observed in the pre-test. There was an increase in the average grades of the experimental group, which suggests that the intervention made was effective since it improved the logical-mathematical thinking of teachers in that group. This result agrees with Albanese & Perales (2020), who conclude that the application of workshops based on ethnomathematics helps to reflect on the sociocultural factors that influence the ideas of mathematics. Also, that leads to the development of a better interpretation of the previous knowledge. Based on those results, they add that the challenge is to help teachers with the transfer of their new ideas to the students.

Another experience in favor of this approach was given by Micalco&Villaseñor (2017), who indicated that teachers intervened associated this way of learning with daily activity. Also, those teachers think it is more useful than the previous conceptual ideas about mathematics, making a revaluation of their knowledge and adopting a new strategy to teach in the classroom. In addition, there are also the results of Albanese & Perales (2017), who conclude that the fact of applying a manual practice motivated the questioning of the participants with respect to mathematics that come up in different contexts and cultural groups and on which they were beginning to conduct their research.

The statistical analysis through ANOVA showed that the difference between the average grades of both groups obtained after the application of the post-test was significant, which is an indicator of the efficacy of the intervention to the experimental group from the perspective of ethnomathematics. Likewise, after a comparison between the teachers' grades of the experimental group in the pre-test and post-test, there was a statistically significant difference. For that reason, it is clear it was directly caused by the intervention made. Results that are consistent with the observed ones were presented by Verner, Massarwe&Bshouty (2019), who applied the ethnomathematical approach to improve the competencies in the geometry of a group of teachers and concluded that teachers understood better the peculiar characteristics of geometry and the approach of specific challenges of the subject. That allowed them to teach their students to integrate visual and formal reasoning and use the geometrical concepts when analyzing and building ornaments, formulating hypotheses and demonstrating their geometric properties. Likewise, Fouze& Amit (2018) demonstrated that the ethnomathematical approach based on folklore games greatly contributes to the students' learning process such as helping them to understand better the study material, increase their motivation, and improve their achievements in mathematics. This process can also contribute to increase the students' sense of belonging to their immediate environment, their values, and cultural traditions. For that reason, teachers must focus on including ethnomathematics in the program to achieve significant learning.

6. Conclusion

The diagnosis of the skill of logical-mathematical reasoning in teachers evinced the necessity to implement strategies to increase the level and, subsequently, influence the teaching in the classroom. The final purpose is to support the students in their learning of mathematics through a new approach that considers the environment and allows them to make a practical association to solve difficult situations, for which the teacher's role is fundamental.

The intervention showed improvements in the teachers' logical-mathematical reasoning, indicating part of the way that must be followed to influence the students. Since Peru is a megadiverse country due to its geography and culture, these differences must be used to teach mathematics based on the ethnomathematical approach.

References

Albanese, V., y Perales, F. (2017). Una experiencia en la formación de profesores sobre concepciones desde una perspectiva etnomatemática. *Revista Iberoamericana de Educación Matemática,* (49), 73-83. http://funes.uniandes.edu.co/17124/1/Albanese2017Una.pdf

Albanese, V., y Perales, F. (2020). Concepciones sobre las matemáticas de los profesores desde una Perspectiva Etnomatemática. *Bolema, Rio Claro (SP), 34*(66), 1-21. http://dx.doi.org/10.1590/1980-4415v34n66a01

Bermúdez, S. (2018). *Propuesta de estrategias metodológicas para el desarrollo del pensamiento lógico matemático en la resolución de problemas tipo saber del componente geométrico - métrico en la competencia de razonamiento con los estudiantes del grado 5° de la Institución Educativa Anchique sede Pueblo Nuevo del municipio de Natagaima – Tolima.* Tesis de Maestría. Universidad de Tolima, Colombia. https://core.ac.uk/download/pdf/185620996.pdf

Blanco Álvarez, H., Fernández Oliveras, A., y Oliveras, M. (2017). Formación de Profesores de Matemáticas desde la Etnomatemática: estado de desarrollo. *Bolema, Rio Claro (SP), 31*(58), 564-589. http://dx.doi.org/10.1590/1980-4415v31n58a02

Castrillón, C., y Ramírez, N. (2016). *Desarrollo del pensamiento lógico matemático apoyado en el uso de blogs en la web 2.0 en los estudiantes de secundaria de la institución educativa real campestre la sagrada familia sede principal del municipio de fresno-tolima 2013-2014.* Tesis de Maestría. Universidad Privada Norbert Wiener, Perú. https://tinyurl.com/yxbaxqt4

D'Ambrosio, U. (1998). Ethnomatemática: Arte ou Técnica de Explicar e Conhecer. São Paulo: Editora Ática.

Fonseca, M., y Ferreira, F. (2015). A Matemática inserida naturalmente no contexto sócio-laboral: um caso de Etnomatemática. *Revemat, 10*(1), 150-161. https://doi.org/10.5007/1981-1322.2015v10n1p150

Fouze, A. Q., y Amit, M. (2018). Development of Mathematical Thinking through Integration of Ethnomathematic Folklore Game in Math Instruction. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(2), 617-630. https://doi.org/10.12973/ejmste/80626

Gavarrete Villaverde, M. E. (2013). La Etnomatemática como campo de investigación y acción didáctica: su evolución y recursos para la formación de profesores desde la equidad. *Revista Latinoamericana de Etnomatemática, 6*(1), 127-149. https://dialnet.unirioja.es/servlet/articulo?codigo=4239662

Herlina, E. (2015). Advanced Mathematical Thinking and the Way to Enhance IT, *Journal of Education and Practice, 6*(5), 79-88. https://www.iiste.org/Journals/index.php/JEP/article/view/20026

Leiva, F. (2016). ABP como estrategia para desarrollar el pensamiento lógico matemático en alumnos de educación secundaria. *Sophia, Colección de Filosofía de la Educación*, 21, 209-224. https://doi.org/10.17163/soph.n21.2016.09

Medina, M. (2018). Estrategias para el desarrollo del pensamiento lógico-matemático. *Didáctica y Educación, 9*(1), 125-132. https://dialnet.unirioja.es/servlet/articulo?codigo=6595073

Micalco, M. y Villaseñor, M. (2017). *Etnomatemática: un enfoque para la formación docente.* Congreso Nacional de Investigación Educativa. Noviembre, 2017. http://www.comie.org.mx/congreso/memoriaelectronica/v14/doc/2203.pdf

Ministerio de Educación del Perú. (2018). *Evaluación PISA 2018*. http://umc.minedu.gob.pe/wp-content/uploads/2019/12/PISA-2018-Resultados.pdf

Mohr-Schroeder, M., Cavalcanti, M., y Blyman, K. (2015). Stem education: Understanding the changing landscape. In A. Sahin (Ed.). *A practice-based model of STEM teaching* (pp. 3-14). SensePublishers.

Nieves, S., Caraballo, C., M., y Fernández, C. (2019). Metodología para el desarrollo del pensamiento lógico-matemático desde la demostración por inducción completa. *MENDIVE 17*(3), 393-408. https://tinyurl.com/y3tzq6q4

Parada, S., y Pluvinage, F. (2014). Reflexiones de profesores de Matemática sobre aspectos relacionados con su pensamiento didáctico. *Revista Latinoamericana de Investigación en Matemática Educativa*, 17(1), 83-113 https://tinyurl.com/y4b8mnyb

Petrovski, A. (1985). *Psicología General*. La Habana, Cuba: Editorial Progreso.

Rico, L. (1998). Concepto de currículum desde la educación matemática. *Revista de Estudios del Currículum, 1*(4), 7-42. https://tinyurl.com/y6fyyk32

Rigalli, A., Lupo, M., Chuliber, M., Lombarte, M., y Lupión, P. (2019). *Uso de herramientas informáticas para la recopilación, análisis e interpretación de datos de interés en las ciencias biomédicas*. Argentina: Universidad Nacional de Rosario.

Romero Saldaña, M. (2016). Pruebas de bondad de ajuste a una distribución normal. *Revista Enfermería del Trabajo,* 6(3), 105-114. https://dialnet.unirioja.es/servlet/articulo?codigo=5633043

Rosa, M., Orey, D., y Gavarrete, M. (2017). El Programa Etnomatemáticas: Perspectivas Actuales y Futuras. *Revista Latinoamericana de Etnomatemática, 10*(2), 69-87. https://www.revista.etnomatematica.org/index.php/RevLatEm/article/view/386

Rosa, M., y Orey, D. (2016). State in the art in Ethnomatematics. En M. Rosa, U. D'Ambrosio, D. Orey, L. Shirley, W. Alangui, P. Palhares y M. Gavarrete (Edits.), *Current and Future Perspectives of Ethnomatematics as a Program* (pp. 11-37). Hamburgo, Alemania: Springer.

Rosa, M., y Shirley, L. (2016). In guise of conclusion. In M. Rosa (Ed.). *Current and future perspectives of ethnomathematics as a program* (pp. 39-40). Hamburg, Germany: SpringerOpen ICME Topical Surveys.

Sachs L., y Santos, F. (2018). Implicações pedagógicas da etnomatemática no contexto da multisseriaçãoemescolas do campo. *Revista Educação Matemática Em Foco, 7*(2), 243-267. http://revista.uepb.edu.br/index.php/REVEDMAT/article/view/4580

Shirley, L. (2008). Ethnomatematics looks back and looks forward. The role of ethnomatematics in mathematics education. In Proceedings of the ICME 10 Discussion Group on Ethnomatematics.

Verner, I., Massarwe, K., y Bshouty, D. (2019). Development of competencies for teaching geometry through an ethnomathematical approach. *The Journal of Mathematical Behavior, 56*, 100708. https://doi.org/10.1016/j.jmathb.2019.05.002

Vilca, E. (2018). *Razonamiento lógico matemático y capacidades matemáticas en estudiantes de 5° secundaria de la IE 5150 - Ventanilla, 2018.* Tesis de Maestría. Universidad César Vallejo, Perú. https://es.scribd.com/document/459585583/Tesis-razonamiento-logico-matematico

Vilchez, J. (2018). La Etnomatemática como recurso didáctico en el proceso de aprendizaje de la matemática en zona rural. *Acta Latinoamericana de Matemática Educativa, 31*(1), 567-575. http://funes.uniandes.edu.co/13598/1/Vilchez2018La.pdf

Yojcom, D., Castillo, E., Gavarrete, M., Tun, M., Pou, S., Flores, W., Morales, L., y Aroca, A. (2016). El programa etnomatemática en Centroamérica y Norteamérica. *Revista Latinoamericana de Etnomatemática, 9*(2), 202-237. https://www.redalyc.org/pdf/2740/274046804012.pdf