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RESEARCH ARTICLE

Mental Maps as a Strategy in the Development of Successful Intelligence in High School Students

Los mapas mentales como estrategia en el desarrollo de la inteligencia exitosa en estudiantes de secundaria

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Summary

Mind maps are usually employed by teachers from all the educational levels as powerful learning strategies. This use enables important pedagogic achievements, but they do not exceed their maximum level, due to the dogmatic use of Tony Buzan's mind map (1996). Situation that would be different if it were entirely internalized, understand and applied. Precisely for that reason, the triarchic theory of intelligence developed by Rober Sternberg (1985) allows students to make decisions in several difficult situations with the suitable use of techniques and orientations in the development of the same intelligence. The research was developed by means of the case study from the qualitative focus, in which through the analysis of the evidences found and the use of an instrument that measured the successful intelligence, its development could be confirmed. However, the empiric analysis was not enough for validating the aforementioned development. For that reason, direct observation was chosen during learning sessions accomplished by the teacher responsible for the strategy to be used, and embodied in the field notebook. Likewise, in-depth interviews were conducted by educational psychologists. It should be noted that the analyzed documents have allowed developing the triangulation not only of evidences but also of methodologies, among them the documentary analysis, in order to reach conclusions that demonstrate how the development of the successful intelligence has been achieved. Finally, it is demonstrated than the use of the techniques of the mind maps with an educational strategy adapted to the applied group, achieves the significant development of the abilities of the analytical, creative and practical intelligence.

Keywords: Triarchic Theory; Analytical Intelligence; Creative Intelligence; Practical Intelligence, Mind Maps.

Resumen

Los mapas mentales suelen ser empleados por docentes de todos los niveles educativos como potentes estrategias de aprendizaje. Empleo que permite logros pedagógicos importantes, pero que no llegan a traspasar su máximo nivel, por el uso dogmático del mapa mental originario de Tony Buzan (1996). Situación que sería distinta si se consiguiera internalizar, comprender y aplicarla en su cabalidad. Precisamente por ello, la teoría triárquica de la inteligencia desarrollada por Rober Sternberg (1985) permite a los estudiantes la capacidad de tomar decisiones ante diversas situaciones problemáticas con el uso adecuado de técnicas y orientaciones en el desarrollo mismo de la inteligencia. La investigación se desarrolló mediante el estudio de casos desde el enfoque cualitativo, donde a través del análisis de las evidencias encontradas y el empleo de un instrumento que midió la inteligencia exitosa, se pudo comprobar su desarrollo. Sin embargo, el análisis empírico no fue suficiente para validar dicho desarrollo; por ello se optó por la observación directa durante las sesiones de aprendizaje realizado por el docente responsable de la estrategia a emplear y plasmado en el cuaderno campo. Asimismo, las entrevistas a profundidad fueron llevadas a cabo por psicólogos educacionales. Cabe resaltar que los documentos analizados, han permitido realizar la triangulación no solo de evidencias sino también de metodologías, entre ellas el análisis documental, para llegar a conclusiones que demuestran de qué manera se ha logrado el desarrollo de la inteligencia exitosa. Por último, se demuestra que el uso de las técnicas de los mapas mentales con una estrategia educacional adaptada al grupo aplicado, logra el desarrollo significativo de las habilidades de la inteligencia analítica, creativa y práctica.

Palabras clave: Teoría triárquica; inteligencia analítica; inteligencia creativa; inteligencia práctica; mapas mentales.

Introduction

Mind Maps

Mind maps created by Tony Buzan stand out among the visual organizers that systematize information with elements analogous to the brain's processing, since this information organizer is linked to the synapse process (union of dendrites) in its placement of branches both in the trace and in their bifurcations. According to Molina y Martínez (2016), it is essential to seek new ways to ensure educational achievements in the vertiginous change that the society is undergoing. One of these ways is the use of Mind Maps, graphic organizers that visually and structurally represent and organize knowledge (p.11). Even for González, Requena, and Díaz (2015), this didactic technique is closely related to the holistic learning model, which, in turn, understands the complete use of the brain (p. 402). The notion of holistic thinking is connected to the three levels (Flavell, as cited in González, Pareja & Gea, 2016): metacognition of tasks or self-awareness, metacognition of strategies or self-awareness of procedures, and personal metacognition or cognitive self-awareness, where their interconnection leads to the self-awareness of complete learning (p.137).

From its appearance and its different theoretical analyses, they can be established as main constituent elements of the central element that triggers semantic associations (radiant thinking), as well as the branches that expand and divide out (creating alternate nodes) according to the mapping need. Its construction logic is based on the neural form, which is why it prefers curved lines to straight lines because of the idea that the brain better assimilates these forms to the rigid and geometric forms of other visual information organizers. It should be pointed out that the mind map incorporates linguistic elements (words, phrases, sentences) as well as non-linguistic elements (chromatic and symbolic coding, etc.) in its design and its implementation. Likewise, within the neural relationship, scholars have agreed to point out that these organizers activate both the left and right hemispheres, unlike other similar organizers that only activate one hemisphere (only the left hemisphere). According to Ardila and Ostrosky-Solis (1991, p. 14), the human brain performs its functions in each hemisphere as follows:

Table 1.
Brain functions by hemispheres.

The Brain's Functional Organization	
Left Hemisphere	**Right Hemisphere**
It encodes sensory information based on linguistic descriptions	It encodes sensory information in images
Temporal analysis	Spatial synthesis
It makes conceptual comparisons regardless of the linguistic content	It makes visual matching without making conceptual comparisons
It perceives details	It perceives forms
It lacks a gestalt synthesizer	It lacks a phonological analyzer
Verbal communication	It processes spatial relations and analyzes the parts in relation to the whole
Linguistic and numerical processing	Perceptual recognition of things
Analytical and sequential thinking	Non-verbal thinking

Montero and De la Morena (2015, p.397) points out that mind maps express in a graphical and nonlinear manner a large amount of information and data of a given subject. This makes it an ideal instrument to take full advantage of the potential of the brain. Likewise, in the classification of how it is decoded (reads and interprets), they are considered discontinuous texts (that are often used to organize the information of continuous texts in the form of traditional readings of books, articles). The images formed in the mind (Perkins, as quoted in Martinez, 2017) allow to categorize the concepts, ordered by criteria, and this constitutes a convincing, creative, cognitive

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influence. Likewise, each of the conceptual notions, which use implies their operationalization (Feldman, as mentioned in Martínez, 2017) of objects, facts and all kinds of ideas that share common characteristics. Mental activity that orders and systematizes the data it receives from outside sources as well as those stored in the internal memory. The genesis of mental images can be activated by evocation or imagination (p.5).

In light of the great acceptance of cognitivism in pedagogical studies, Tony Buzán (as quoted in Blanco, 2017) assumes the logic of the mind maps as an analytical method that makes it easier for those who use it to systematize with great simplicity and certainty the complexity of thought, as well as the maximum use of the human mental capacity. Any of these maps are simple ways of using the flow of data and information between the brain and the outside, constituting, in turn, an effective and creative tool to generate more thought and imagination (p.26).

Parts of a Mind Map

Theorists have agree on the following basic components of a mind map. This study will link these basic components to the notions of the triarchic intelligence, being understood as analytical, practical and creative abilities (Sternberg, 1985):

- IOB (Basic Ordering Idea): It is the main component of the mind map, from which the semantic and conceptual associations of the topic to be organized and reflected in the map will expand. According to Ontoria et al, 2006 the IOB is the point from which the secondary ideas will be organized hierarchically. Linked to the triarchic intelligence, the IOB allows the analytical starting point and its subsequent bifurcation. It stimulates creativity since it synthesizes or semantically condenses the essential information reflected in the map by using an iconic and chromatic element. And finally, it is practical because it provides the design with a simple hierarchization from the center outwards.
- Branches: It is the structural and subcategorical interweaving of the map. Associations and subdivisions are established through the branches according to the design. These branches radiate out from the center (Ontoria et al, 2006). From the triarchic logic: it allows to specify the analysis in detail. It is practical because it can subdivide as many times as needed to better clarify or explain a certain concept. And from the creative point, the thickness, color, and tone of the branches can be designed very freely to emphasize its trace.
- Associative nodes – Secondary Ideas: Secondary ideas are a kind of conceptual nodes that will, in turn, create subdividing branches. They are small focuses of radiation subordinated to the main one (BOI) that meet an analytical purpose in the triarchic intelligence because they are subcategorical dividing points of a thematic whole for better understanding. A creative purpose because it allows the individual to place within these nodes chromatic or iconic elements to summarize or synthesize a high semantic load. And practical, because thanks to its flexibility, the design of the mind map can be subdivided into hierarchically and sequentially disaggregated concepts. The labels in the associative nodes should be expressed in a clear and precise manner (Buzan, 1996, p. 119).
- Coding: The use of symbolic, chromatic or iconic coding is important in the design and subsequent use of any mind map. This coding allows the establishment of associations with the triarchic intelligence in a practical way: by using cultural and common elements expressed in icons, symbols and chromatic signification. In an analytical manner, by being used in the codes, internal subdivisions up to the necessary levels for a better understanding of the mind maps. And finally and most importantly, it infinitely expands the creative possibility of the human thought by proposing iconographic and pictorial codes and allegories of any kind, and taking advantage of them in the mind map. This coding is usually concretized by the use of spheres, ellipsis, underlines, suns, parts of the body and other simplified graphics that save text and finish up ideas (Buzan, 1996). As well as numerical symbols, arrows, geometric forms and others to hierarchize, orient or link the nodes in the mind map (Ontoria, 2006).

In consideration of all the above, it is possible to speak of the use of the mind maps for successful Intelligence as long as this organizer is used as the conscious and directed exercise of the three triarchic abilities proposed by Sternberg: analytical, creative and practical abilities.

Intelligence

Intelligence, which concept has evolved throughout history, is linked to measurement, since Binet, who developed instruments aimed at measuring the great mental processes; Binet and Simon, in 1905, who created the measurement scale, which results showed children who needed special education; Stern, in 1911, developed the concept of intellectual coefficient; Terman, in 1916, developed the Stanford-Binet scale developing the scale of intellectual coefficient; Spearman, in 1904, developed the "G factor of intelligence". Figure 1 shows the correlations of the G factor with the S factors.

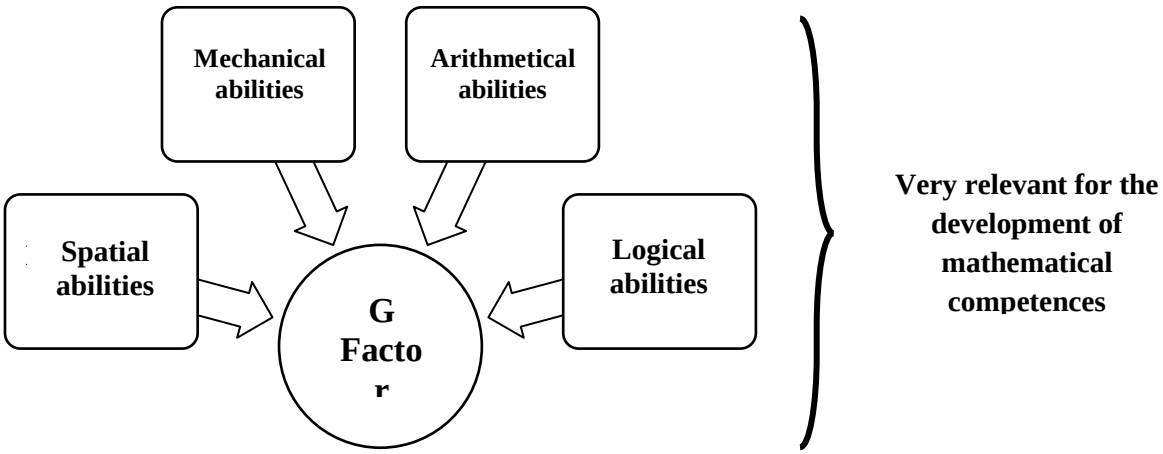

Figure 1. Spearman's Model

Correlation of the G Factor with the S Factors

The correlations among the different factors are developed here. Vernon, in 1964, developed intelligence according to the cognitive abilities, from the g factor to specific factors. Catell, in 1967, developed the theory of fluid and crystallized intelligence aimed at solving problems. He considered the factors of "actors of visual perception, short-term memory, long-term storage and retrieval, processing speed, auditory processing, quantitative reasoning, and reading and writing skills" (Pérez & Medrano 2013, p. 107).

Gardner, in 1983, proposed multiple intelligences: linguistic, logical-mathematical, naturalist and spatial intelligences. This process leads us to define intelligence as people's capacity to solve problems, in which a set of abilities and capacities to adapt to the environment is manifested (Rigo & Donolo 2013, Ardilla 2010, Anastasi 1998).

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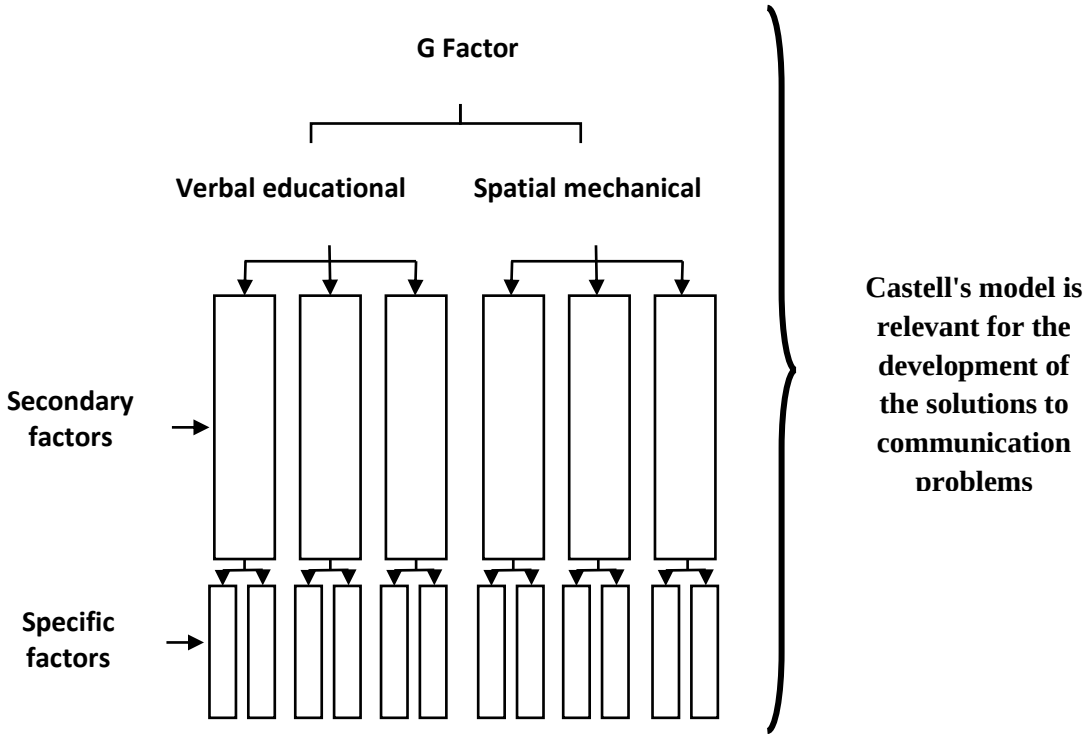

Figure 2. Castel's Model of Fluid Intelligence, 1967.

Martín and Boeck (2000) conduct emotional intelligence studies. These studies define emotional intelligence as the understanding of emotions by the same people to improve the quality of life.

Triarchic Intelligence

It was proposed by Sternberg (1985), aimed at understanding the problem-solving processes. Kholer (2008) carried out the psychometric analysis of the instrument proposed by Sternberg, Sternberg Triarchic Abilities Test (STAT), which results demonstrated the reliability and validity of the instrument, responding to the "G" factor-focused model, which is insufficient for some researchers because it does not explain how intelligence processes are produced. Later, Gardner and Sternberg, the multifactorial model, such as musical intelligence and social awareness, among others.

Within this framework, Sternberg (1985) proposes the "Robert Sternberg's Triarchic Theory of Intelligence", which focuses on cognitive processes and where information is coded, stored and combined in order to solve problems or respond to complex situations. Hence, it is proposed that the achievement of cognitive competences requires human beings to have a balance of intelligence in its three components: "analytical, practical and creative abilities".

With respect to analytical abilities, it is necessary to carry out the processes of planning, executing and evaluating mental processes. The practical ability develops the processes of codifying, selecting and automating these mental processes. The practical ability, where the creativity processes are developed, where ideas are applied in the reality, that is to say, problem-solving.

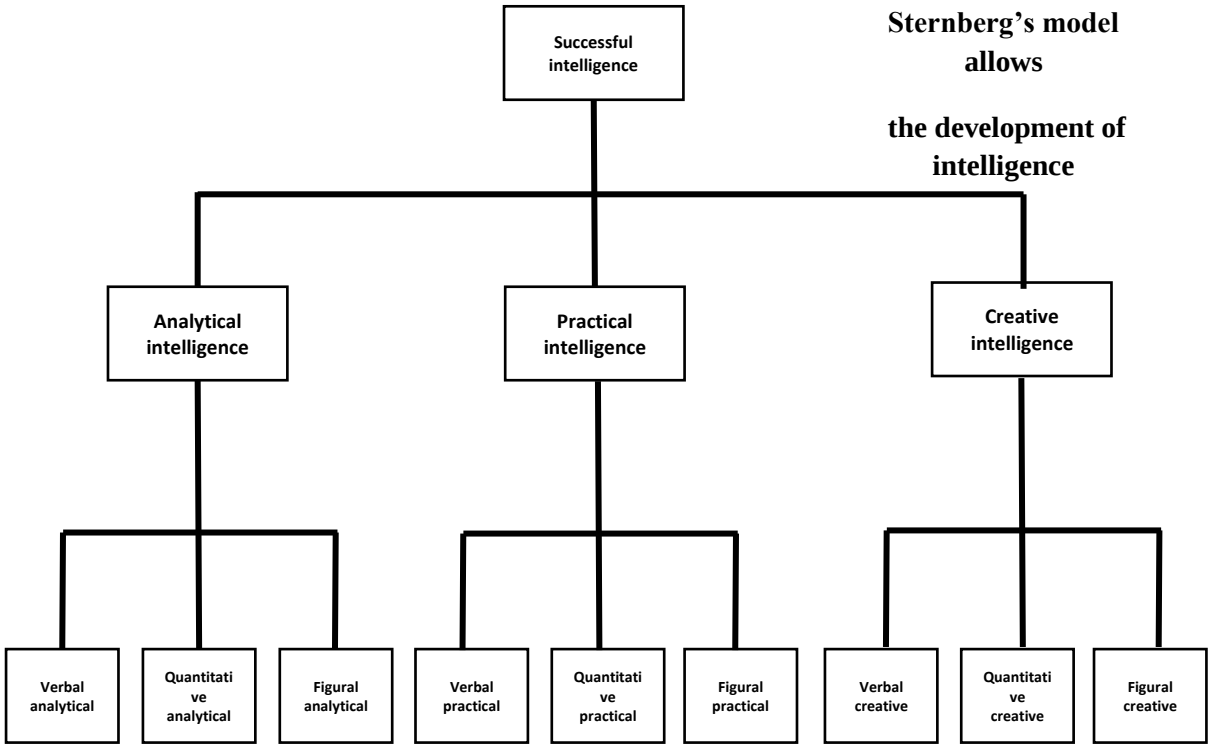

Figure 3. The three factors of successful intelligence, proposed by Sternberg.

Method

The research was carried out from two perspectives, although executed simultaneously. The first perspective used a quantitative approach, through applied research, which is also called "empirical" where knowledge is applied to a reality and which result validates to broaden that knowledge, for our case the use of the mind map technique in the development of triarchic intelligence (Sánchez & Reyes 2015; Vara 2015; Hernández, Fernández & Baptista 2014; Bernal, 2011). Likewise, the quasi-experimental design was used, with pre-test and post-test, for the experimental and control groups. This type of design allows to compare both groups, where at the beginning the control group has similarities with the experimental group, making it possible to determine if there are differences as a result of the application of any program. (White & Sabarwal, 2014). The population was made up of forty students of a secondary education institution of Cercado de Lima. Both the experimental and control groups were made up of twenty students. The Sternberg Triarchic Abilities Test (STAT) instrument, validated by Kholer (2008), was used, with a KR reliability of 0.810, establishing the enormous reliability of its application. The statistics obtained at the end of the process showed a difference between the experimental and control groups, as well as in the pre-test and post-test.

Simultaneously, qualitative research was used, through case study, which, according to Simons (2011), is characterized by being an exhaustive study, where the issue is evaluated through different perspectives, but in a development context, in order to have a holistic understanding of the issue to be studied. "Yin 1994...indicates five categories of case study: explanatory, descriptive, illustrative, exploratory and evaluative" (Simons, 2011, p. 43). In our case, the explanatory study was used in which the causes of the issue are established.

The procedures used a set of learning sessions for the experimental group, where the mind map technique was employed, from the teaching process for its elaboration, both manual and digital, making it possible to design a set of strategies to develop and strengthen students' successful intelligence. Also, during the implementation of the sessions, diverse qualitative

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techniques were used, such as observation, interviews with the participating students, documentary analysis of the planning of the sessions, evaluation instruments, and the learning outcomes.

Results

The first statistics obtained in the pre-test and post-test exhibit the different levels of successful intelligence in its three dimensions: with respect to analytical intelligence, there is a significant progress from low to medium levels in 10% of students; with respect to creative intelligence, it is evidenced a movement from low to medium and high levels in 10%, and with respect to practical intelligence, it is evidenced a movement from low to medium levels in 3.3% of the cases. These results show the improvement of the analytical, creative and practical abilities in the students due to the application of the mind maps.

Table 2.
Pre-test and post-test of successful intelligence in the students of the experimental group

	Development of analytical ability		Development of creative ability		Development of practical ability	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
	%	%	%	%	%	%
Low	13.3%	3.3%	20.0%	6.7%	3.3%	0.0%
Medium	76.7%	86.7%	70.0%	80.0%	86.7%	90.0%
High	10.0%	10.0%	10.0%	13.3%	10.0%	10.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

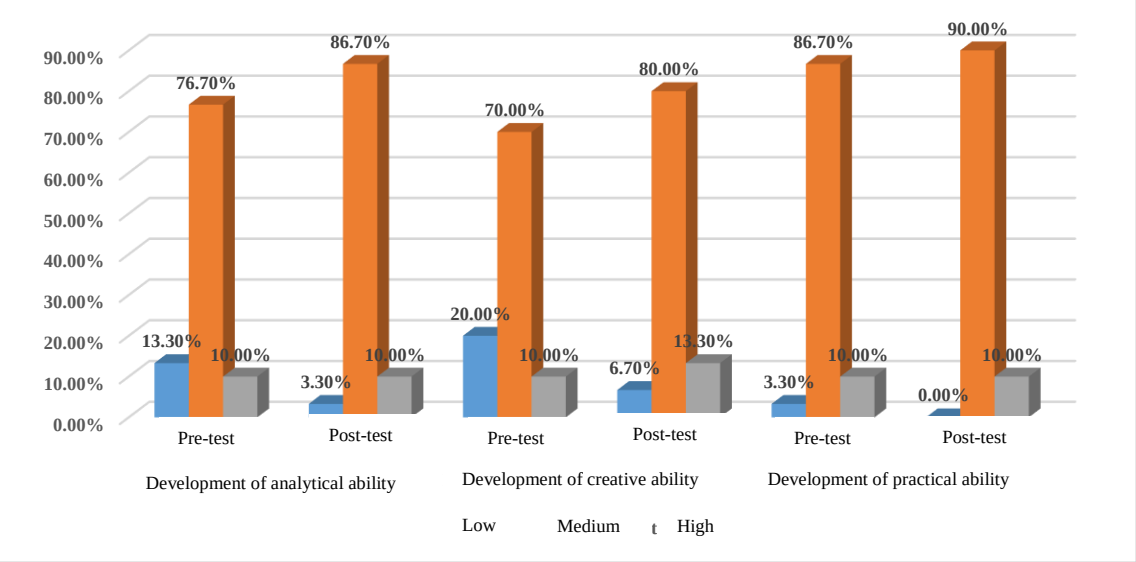

Figure 4. Pre-test and post-test of successful intelligence in the students of the experimental group

Likewise, the test statistics used to observe the difference between groups - Mann Whitney's U - show that there are significant statistical differences between the control group and the experimental group in the three abilities of successful intelligence, where the analytical ability presents the bilateral significance of .000 and a T table value of -4.004, indicating that the experimental group has improved by the use of the mind maps. The same is shown in the creative ability - .000 and -5.144 and practical ability - .000 and -4.397.

Table 3.
Test results of successful intelligence in the students of the experimental group

	Analytical intelligence		Creative intelligence		Practical intelligence	
Test statistics	Control - experimental Pre-test	Control - experimental Post-test	Control - experimental Pre-test	Control - experimental Post-test	Control - experimental Pre-test	Control - experimental Post-test
Mann-Whitney's U	361.000	182.500	296.500	108.500	321.000	154.500
Wilcoxon's W	826.000	647.500	761.500	573.500	786.000	619.500
Z	-1.344	-4.004	-2.366	-5.144	-1.945	-4.397
Asymptotic sig. (bilateral)	.179	.000	.018	.000	.052	.000

The applied statistical data show the students' significant progress with respect to the abilities of successful intelligence. A baseline is established with the pre-test results. Both groups were given separate explanations with the presence of the researcher. At the beginning, the purpose of the research was explained to the students of both groups, and most of them showed enthusiasm and desire to participate. The teacher was given in a simple manner the details of the steps and procedures that would be carried out during the learning sessions, showing that the learning sessions were planned in an adequate manner.

In evaluating these sessions, it was noted that they were formed by the following aspects: the title of the session, competences, capacities and indicators to be developed, didactic sequence, closing, materials and resources where "storyboarding" stands out, which is a set of figures that detail the procedures to be followed. All of them showed coherence in their construction, highlighting the methodological strategy to follow. In the current contexts, planning requires looking towards the future in order to make coherent decisions, strategies that make it possible to achieve the proposed objectives (Aguerrondo, 2014).

In the first learning session of the experimental group, several reading techniques were used, emphasizing the use of underlining, synoptic tables for the localization of relevant aspects, making it possible to determine the main and secondary ideas of the text. Next, they learn the use and elaboration of the mind map, where the students start to trace the relevant aspects of the reading in the scheme they develop. It is important to highlight the use of colors and icons for its elaboration.

At the beginning, the students are enthusiastic, but during the session, they show difficulties to learn it. They stated at the end of the first session that they found the mind maps attractive and that they allowed them to participate actively in the class, but that they still did not understand how to articulate the reading with the organizer. The teacher explained that it was the initial phase and that because the technique was used properly, there were still some gaps to fill. Also, how to relate the analytical skills of the map is just beginning. This is why Simons (2011) explained that in this phase it is fundamental to negotiate based on the statement of the opinions of the participants, giving them pertinent and adequate answers to maintain the motivation and active participation of the student.

In the in-depth interview with the didactic expert Dr. Sanchez, she explained that good planning implies for the teacher to follow a series of heuristic or algorithmic procedures, which will allow the teacher to achieve the didactic objectives raised in the session. Although the teacher's effort to follow the procedures indicated in the session, there was some resistance in the students. In a dialogue with them, they indicated that they did not understand some procedures performed in the class.

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From the second to the fourth learning session, the teacher has improved his/her communication with the students and they, in turn, better understand the process of building learning. This also denotes the process of developing triarchic intelligence abilities. In the analytical ability, the students begin to conceive the mind map holistically, reading as a whole and logically articulated parts. And this is expressed in each bifurcation and icon made. This also means the development of creativity, expressed in the use of colors, iconographies, organizing the analyzed information and making it coherent. Finally, they understand the usefulness of this work because they visualize the systematization of the analyzed reading and the results obtained in the formative evaluation.

Three processes occur simultaneously: the improvement of the application of the technique in the elaboration of the mind maps, the development of the analytical competences, and the development of the triarchic abilities. Undoubtedly, experience shows us that the indicated variables are closely related, giving coherence and internal validity to the research, through the deep description of the process.

The psychopedagogical expert Dr. Menacho explains that in order to develop intelligence in students, both academic and motivational stimuli are fundamental. For example (she states that) tasks are attractive, breaking their own fears in their realization, they do them themselves, where they really express their joy when they achieve the expected goal and all this combines is their motivation and driving force to continue learning.

From the fifth session, the evolutionary process of their learning was developed without reaching the expected goals. However, what has been achieved shows us that mind maps are key tools for the development of triarchic intelligence, where the results indicated that a small group make no progress in the development of intelligence and that a largest group was located at an intermediate level.

The experts consulted, both Dr. Sanchez and Dr. Menacho, agree that this process needs considerable time and that it would be magnificent if it starts from the first school grades, thus allowing to develop not only skills but also intelligence.

In implementing the learning processes, it was noted that the teacher used active methodological strategies, where the interaction with the students is permanent, permanently stimulating their performance, analyzing with them the chosen readings and using the mind maps for the purpose of the classes.

Discussion

Mind maps as a strategy in the development of intelligence in high school students show us that they are excellent didactic tools. González et al (2015) conclude that they are an effective technique to develop interpersonal relationships to the fullest, but they are more than that, they are elements of successful intelligence growth.

Martínez (2017) establishes a high influence between mind maps and creative thinking. However, this article extends this affirmation to the scope of intelligence processes, which are more and which do not deny but include, among others, the creative reasoning. In agreement with Kholer (2008), it can be added that learning strategies allow the development of triarchic intelligence. Likewise, the quantitative and qualitative evidence leads us to affirm that the pertinent and adequate use of strategies has contributed to the global development of successful intelligence.

According to Molina and Martinez (2016), mind maps constitute a very effective didactic strategy to achieve the desired significant learning. An indispensable requirement to achieve the

desired significant learning. However, integral progress is expected only with the consolidation of successful intelligence (Kholer, 2008b; Rigo & Donolo, 2013).

And finally, the time factor can be a factor to consider in other researches, where a greater number of learning sessions are planned, including greater strategies of reading comprehension aligned to the use of mind maps. Likewise, the inclusion of a greater number of hours in the use of software so that they have tools to complement the mind map and if it is applied to student groups, the selection of a battery of readings, according to grade and age, that makes it possible to obtain the expected results.

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