



Review article

Perception channels and cognitive styles: opponents, followers or learning allies?

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ABSTRACT

This article presents the findings in the process of evaluating the relationship between perception channels and cognitive styles, from the analysis of conceptions over time and their involvement. Establishing through an experiment, and applying two didactic strategies, the associations with learning. Channels are characterized with VAK, Styles with CHAEA, and Performance with a pre-test/post-test design. It was shown that channels and styles are allies that independently encourage the teaching-learning process. Outcome shows that people with multiple channels and styles develop more skills, achieving better results. Games as ludic activities stimulate all channels, and favor the construction of knowledge, thus improving performance with positive differences in p-values between 0.014 and 0.022.

1. Introduction

The line that differentiates channels of perception and cognitive styles is quite thin and, in many cases subjective, so much, that it is not known if they are opponents, followers or allies, in fact, some authors question whether the channels can be considered cognitive styles (Gamboa-Mora, Briceño-Martínez and Camacho-González, 2015). Understanding the meaning, difference and impact of perception channels and cognitive styles (known as learning styles) (Rivera et al., 2019) on academic performance, is an interesting exercise that can guide practices inside the classroom, as long as it is possible to understand that the teaching-learning process is dialogic, in which reality is interpreted through the staging of content, knowledge and experiences between students and teachers, which interact with the purpose of learning (Gamboa, 2017).

At this point in the interpretation, it makes sense to recognize that meanings are not something fixed and steady, they are historical products that change over time (Kuhn, 1983). Paradigms, in both natural sciences and social sciences do not compete in the discourse of science;

old paradigms are rarely replaced by counterfeiting, but new and old paradigms tend to coexist (Conde-Pumpido, 2019).

To begin discussion, perception is the location and collection of information obtained from external environments, the channels of perception are responsible for carrying out the action of research and organization of information, which contributes to the learning process. For Dunn and Dunn (1978), channels reflect the way in which basic stimuli affect a person's ability to absorb and retain information. In this regard, Azcoaga (2010) quoted by Merchán and Henaó (2011), points out that in order to generate learning, it is necessary to articulate a set of neurophysiological activities in the central nervous system, which are; sensory perception, attention, motivation, memory of short and long term habits, skills and competencies.

There are three channels of perception: visual, auditory and kinesthetic (VAK), they define preferences in the way people receive information to interact with reality. Visual; are people who perceive through the sense of sight, they privilege actions such as: reading, imagining, drawing, relating ideas and concepts; its distractors are movement and disorder. On the other hand, Auditory; are people who perceive through the sense of hearing, they privilege actions such as: listening, talking,

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debating, speaking in public and singing; their distractor is noise. Finally, Kinesthetic; are people who perceive through the sense of touch, they privilege actions such as: touching, moving, walking, dancing and performing physical activities; their distractor is noise (Gamboa, García and Ahumada, 2016; Cazau 2005; Escobar 2010).

Recent experimental and neuroscientist research indicates that there are complex connections between perception, cognition and learning. The perceptual mechanisms are complex; the channels provide abstract descriptions of reality. Perceptual representations are modeless (they do not depend on the sensory modality by which they have been perceived) and the perception is selective (cognitive bias consisting of the selection of an object, disregarding the set of information). The information perceived makes viable the accomplishment of cognitive tasks, including the abstract and symbolic domains, the first referred to social reality and the second to physical reality (Kelleman and Massey, 2013).

It is important to point out that there are two theories about perception and perceptual development: the empiricist theory, where significant perception is a product of associations between sensations and actions, from this perspective all perception is a cognitive act, which constructs meaning by associating new sensations and connect them with previous sensations (Berkeley, 1709/1910, Locke, 1690/1971, Titchener, 1902, cited by Kelleman and Massey, 2013). And the cognitive theory, where all significant perception is a product of learning, implying sensations and associations, sensations are associated with previous experiences and everyone learns through association, which is the basis of Perceptive Learning (Kelleman and Massey, 2013).

Now, to continue the controversy, the concept of cognitive styles has changed over time and has been modeled according to the field of application on which it is outlined, initially the term was introduced by psychological currents; in the 1950s Witkin, Holzman and Clein, Eriksen, Golstein and Scheerer gave cognitive styles an individual character; Claxton (1978) later defined them as the result of using stimuli in learning context.

Subsequently, Hunt (1979) determined that they were the conditions in which one is most willing to learn and in the same year Gregor recognized them as indicators of the way of learning. Schmeck (1988) clarified that they were the responses of an individual to perform a task, Grasha (1998) pointed out that they correspond to preferences for learning in different environments and experiences; the following years, Hederich and Camargo (2000) and Gentry (1999), related them to strategies for information processing, reinforced by Askew (2000) who associated them with the intellectual functions related to learning. Finally, Quirog and Rodríguez (2002), referred to them as the integration of cognitive and affective processes to learn, and Cazau (2005), stated that they are influenced by environmental factors and that they are non-static.

According to Kolb (1984), there are four cognitive styles: convergent, divergent, assimilator and accommodator. Honey and Mumford (1986), started from Kolb's theories, but described the styles in more detail and renamed them as active, thoughtful, theoretical and pragmatic. They considered that a way to increase learning effectiveness is to identify the preferred cognitive style, understanding that a subject can develop different styles according to the characteristics of their experiences.

The characteristics and description of each style are: Active; they are described as people who fully and without prejudice are involved in new experiences, having the characteristics of an animating, improvising, discoverer, risky and spontaneous subject. Reflective; they are described as people who observe experiences from different perspectives, collect data and analyze it carefully, they possess characteristics that belong to people who act in a weighted, conscientious, receptive, analytical, exhaustive, patient way, and who are sustained from observation. Theoretical; is described as a person who adapts and integrates observations within logical and complex theories, incorporating the characteristics of a methodical, logical, objective, critical, structured subject, who analyzes data, is disciplined, perfectionist and is based on concepts. Pragmatic; they are people who put ideas into practice, taking advantage

of any opportunity to experiment; and being practical, direct, effective and realistic (Montes and Gutiérrez, 2017).

All of the above is related to the Dialogic Learning process that is based on communication, which is made more efficient through didactic strategies that stimulate the channels of perception as the first means of interaction with reality. In this regard, Molina (2005) points out that the educational process focuses on different expressions of language: oral, written and iconic. The communication involves verbal and nonverbal forms, it is effective through words, tone of voice, gestures, hand movements, posture and paralinguistic that refers to the signals present in a linguistic broadcast, affirming or contradicting the communicative sense (Meneses, 2011; Serrat, 2015; Gamboa et al., 2017). In this regard, Hernández-Muela et al. (2004) quoted by Meneses (2011) defines communication as a dynamic act in which subjects come into contact, involving minds and realities, configured as a resource that leads or not to learning.

A consequence of what has been described is the proposal of learning as the product of interaction with reality and the processing of information, it is achieved individually and socioculturally, establishing associations between theories of learning and theories of representation or interpretation that teachers perform in the teaching-learning process to build knowledge, in accordance to description in Table 3 (Poza, 2006, cited in Gil, 2014).

Through time, currents of thought or schools that revolve around the concepts that are built around learning and the interpretations that teachers have in the teaching-learning process, with respect to how the exegesis of the reality.

Learning theories have evolved over time, incorporating more elements into the process, starting with behaviorism until reaching sociocultural theories. Behaviorism takes behavior as its central element, the main exponents are Watson, Pavlov, Skinner and Bandura. It is a psychological current that was based on the changes that are experienced in people's behavior thanks to stimuli of a natural or conditioned type (artificially recreated), declaring the existence of three types of conditioning.

The first, Classical Conditioning, in which one learns by associating stimuli with responses (Watson and Pavlov, 1913, cited in Ulate, 2012, and Leiva, 2005); the second, operant conditioning, in which learning is considered not to be long-lasting and requires reinforcement (Skinner, 1970, cited in Plazas, 2006) and the third, Vicarious or Observational Conditioning, in which learning is rote, repetitive and responds to the observation of the consequences that a behavior has for another person, considered an imitation learning that develops through the following phases, attention, retention, reproduction and motivation (Bandura, 1977, cited in Palacios, 2015).

On the other hand, constructivism as a school of thought is opposed to behaviorism, the first constructivist current is the Cognitivism, in which the central elements are the cognitive processes: remembering, understanding, applying, analyzing, evaluating and creating, it is assumed that for Learning is necessary to execute the aforementioned processes, that is, learning is related to mental processes.

In the Cognitivism current, Piaget, Bruner, Ausubel, Novak and Gagné are recognized as the main exponents. It is a psychological current where learning is considered to be the product of mental processes, the different authors make school because they have as a fundamental principle the cognitive process and not memorization, although there are marked differences between them. In the epistemological axis, it is articulated with the interpretative theory, which in turn is an implicit theory of the teaching-learning process that seeks to achieve the closest copy to what is taught, tending towards the active participation of the student that generates an execution of cognitive processes. For this current, the knowledge object approaches the real object, although schemas are modified (Cossío and Hernández, 2016).

For Piaget, the development of cognitive skills is carried out in stages, the sensorimotor stage; from 0 to 2 years, specific operations from 2 to 12 years and formal operations from 12 years onwards

(Saldarriaga-Zambrano et al., 2016). For his part, Bruner talks about learning by discovery, promoting understanding, where the student discovers and links with what he already knows, knowledge depends on exploration (Pardo and Benito, 2013).

On the other hand, Ausubel talks about the significant learning that occurs through conceptual assimilation, the individual learns receiving verbal information and relating it to previous knowledge, being two the indispensable factors; foreknowledge and new material, in which new information is connected to a relevant concept, known as "subsumer", which exists in the cognitive structure and which functions as an anchor point, to which the new concepts join, generating a more elaborate structure, selectively activating new information, interactively and integratively generating new more powerful subsumers (Villaruel and Mazo, 2020; Flores-Espejo, 2018).

For Novak, preconceptions are represented by the cognitive structure, which function as a support to generate meaningful connections with new concepts, however, this whole process is not generated in a unidirectional way, but rather is fed back in a bidirectional way, since prior ideas are not eliminated, instead, assimilation occurs by the integration of both knowledge (Capilla, 2016).

Finally, Gagné determined five categories resulting from learning: verbal information, intellectual abilities, cognitive skills and strategies, motor skills and attitudes. In addition, he proposed that depth of learning is a construct that can be organized hierarchically based on its complexity: motivation, apprehension, acquisition, retention, recovery, generalization, performance, and feedback. This organization allows differentiating effectively different components of learning understood as a cumulative or construction act (Tang et al., 2020).

The humanist trend is based on the fact that the human being must be considered as a whole, it is not just mind, one of the most recognized exponents was Gardner, who in 1983 stated that intelligence does not depend on a single factor, which is the summation of multiple intelligences, that combined, generate the intellectual profile, which is unique for each person, demonstrating that we are all different and that not all of us learn in the same way.

12 intelligences have been recognized, product of adjustments and reformulations to Gardner's theory, the initials formed by the intelligences: linguistic, logical-mathematical, musical, kinesthetic, spatial, intrapersonal and interpersonal; the others, the secondary ones made up of: naturalistic, pictorial, sexual, digital and existential or spiritual (Gamboa et al., 2013; Nadal, 2015; Cejudo et al., 2017). In the epistemological axis, it is articulated with critical theory, which in turn is a theory of the teaching-learning process that seeks the interpretation of knowledge, active participation and generates a reflective student. From this point of view, the object of knowledge is not equal to the real object, it depends on the perspective with which it is analyzed (Silva and Mazuera, 2019). The humanistic current is based on the fact that the human being must be considered as a everything is not just mind, one of the most recognized exponents was Gardner, who in 1983 stated that intelligence does not depend on a single factor, which is the sum of multiple intelligences that combined generate the intellectual profile, which is unique for each person, demonstrating that we are all different and that not all of us learn in the same way.

Finally, the social current represented by Vygotsky who affirms that cognitive development is achieved in sociocultural interactions, mental activity is exclusively human, it is the result of social learning, the internalization of culture and social relations (Vera-Monroy, Mejía-Camacho and Gamboa, 2020). Epistemologically it belongs to the post-modern theory that is related to the teaching-learning theories in which knowledge is built, with the active participation of the student and the search for consensus. In this context, the knowledge object is not equal to the real object, it depends on the perspective with which it is analyzed, consolidated and validated by social consensus (Gil, 2014; Villegas and González, 2005; Sánchez-Vidal, 2017).

Authors as teachers join the Social Constructivism Current, implementing a playful strategy that enables the construction of learning from

the socio-cultural perspective, aiming to enhance the individual skills of the participants, thanks to the interaction between those who facilitate the process and those not understanding that the object of knowledge requires an interpretation and validation by consensus.

To highlight learning, academic performance is commonly assessed, a polysemic concept that for some authors corresponds to the grades students are awarded in a training process, while others such as Martín et al. (2016), state that performance is more than a numerical grade, it is a complex process in which different dimension aspects of students converge, such as personality, emotional intelligence and the meaning of life, this was reinforced by Núñez and collaborators in 2018, who confirmed that performance is related to social and personal skills, in accordance with Gil (2014), Villegas and González (2005), and Sánchez-Vidal (2017).

With the purpose of having an efficient communicative process in the classroom and a better academic performance, Playing has been considered as a tool that enables learning, through collective work, where the capacities to solve a problem next to "the most capable" are enhanced (Vera-Monroy et al., 2020). Playing leads itself to a series of behaviors, such as imitation, which represent various evolutionary trends, and for this reason, it is a very important source of development and appropriation of the sociocultural sense of Human activity (Vygotsky, 2008, cited by Gallardo and Vásquez, 2018).

This article aims to answer the following question: What associations are established between perception channels and cognitive styles to facilitate learning, evaluated in terms of academic performance using a playful teaching strategy in university students?

2. Methodology population

The study was carried out with a population of 65 students which represent 100% of those enrolled in the 3 courses, guided by 3 different teachers, of the organic chemistry subject that has a dedication of 3 credits (144 h), in a Colombian university. The population was divided into two groups at random, of which, 19 students who are part of a course, were designated as the control group (C) who learned the subject of carbohydrates through a traditional class, in which the teacher presented the contents in a lecture format. The experimental group (E) was made up of 46 students (enrolled in the two remaining courses), who learned the subject through a playful strategy playing with the C=O Carbohydrates tool, designed with the purpose of stimulating the channels of visual, auditory and kinesthetic perception, promoting effective communication and teamwork. The Human Subjects for the study, signed the informed consent in accordance with the Colombian Data Protection Law (Law 1581 of 2012) and the guidelines of the ethics committee of the Universidad Manuela Beltrán University.

2.1. Characterization of the participants

To establish the preferred perception channel, the VAK questionnaire designed by Felder and Silverman (1988) was used, which has had several adaptations (Hervás and Castejón, 2006; Velasco, 1996; Chalisa et al., 2000). The instrument adapted for this process consists of 10 items in which everyday situations are contextualized, Respondents must recognize and select the sense through which they perceive them. It was validated by experts with a Cronbach alpha reliability index of 0.77 (cited in Gamboa et al., 2015).

The preferred cognitive style was defined with the CHAEA instrument, which was designed by Honey and Mumford (1986) and later modified by Alonso (1991), it consists of 80 items and holds the four fundamental cognitive styles. Twenty items correspond to each style, distributed randomly, and respondents must select "agree" or "disagree" according to their appreciations, and if these approximate with more or less fidelity to the statements exposed in each item (Correa, 2006;

Gamboa et al., 2017). The questionnaire was validated reporting Cronbach reliability indexes of 0.627 for the active style, 0.725 for the reflexive style, 0.658 for the theoretical one and 0.588 for the pragmatic one (Alonso et al., 1999).

2.2. Validation of the relationship between perception channels and cognitive styles and associations with learning

The academic performance of the participants was established through a pre-test/post-test experimental design with 12 multiple-choice questions, which evaluated the generation of cognitive processes required for learning the subject (Vera-Monroy et al., 2020), the results are presented as a percentage.

The evaluation of the relationship between perception channels and cognitive styles was performed through Spearman's rank correlation coefficient test, in the SPSS 25 software program.

To establish the significant differences in the post-test of groups C and E according to perception channels and cognitive styles, the Kruskal-Wallis Test was performed in MiniTab Statistical Software.

3. Outcomes

The results obtained from the implementation of the VAK questionnaire allowed defining the preferred channel of participants according to the highest score in: visual (V), auditory (A) and kinesthetic (K), for the cases in which the same score was presented in two channels, they were classified with what from now on will be recognized as Multiple Channel (MC) corresponding to the results of Rodríguez-Cepeda (2016) research. The percentages of the results are shown in Figure 1.

The cognitive styles were established with results from CHAEA questionnaire, classifying the population in: active (Ac), reflexive (Re), theoretical (T), pragmatic (Pr), and for those who presented the same score in two or more styles, Multiple Styles (MS) category was created. Figure 2 shows its percentage distribution.

The relationship between perception channels and cognitive styles is shown in Table 1, where the little correlation that exists between the analyzed variables is evident, showing that no association was found between channels and styles for the studied population.

To compare the academic performance from the implementation of the game, a pre-test (Pre E and Pre C) and post-test (Pos E and Pos C) were performed with groups E and C, the results are presented in percentage values in Figure 3 and the Statistical Tests of the two groups are shown in Table 2.

The relationship between perception channels V, A and MC with student performance is shown in Figure 4, where the percentage change is evident before and after applying the teaching strategy.

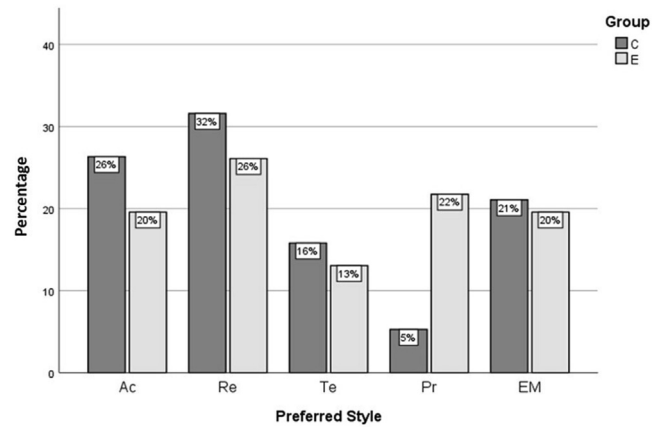


Figure 2. Preferred cognitive styles.

The relationship between the cognitive styles Ac, Re, T, Pr and MS with the performance of the population is shown in Figure 5, where the percentage change is evident before and after the strategy.

The significant differences between Pos E and Pos C for channels and styles are shown in Table 3.

4. Discussion

Populations differ in their characterization of preferred channel (Figure 1), group E shows a marked tendency to preferred channel V, while group C tends to channel A. In groups, students with channel K are 1 in C and none in E, while there is a high presence in channel V and A, the number of students with MC is the same in groups E and C. The low presence of students with channel K may be due to the fact that the population is in a range of 17–22 years, being from generation Y (Ruiz, 2017), which suggests that they went from traditional to internet and were immersed in it, wanting to always be connected, causing them to neglect the movement, all of the above reinforces the conclusions made by Cazau in 2005.

Regarding cognitive styles (Figure 2), the study population shows similar trends, the largest difference being found for the pragmatic style, while the multiple style presents equal percentages.

The target of this study is to validate the relationship between perception channels and cognitive styles, taking into account that the two converge in the learning process, however, it is necessary to previously understand what each of these concepts represents, given that the theories of learning and the theories of the construction of knowledge have evolved over time (Gil, 2014; Leiva, 2005; Sánchez-Vidal, 2017), the two concepts have been mixed to the point of losing their identity, creating a dilemma in the science discourse in which the two coexist and are interpreted in the same way (Kuhn, 1983), this situation itself is not an error, the error lies in forgetting that knowledge is a social construct and as such it should be subjected to a continuous process of validation, so that once the transformations are made, the postures are adjusted and the concepts are transcended.

Based on the above, regarding learning, it has been declared that it happens at different levels or steps that must be intertwined to achieve successful processes (Wischgoll et al., 2019), within this categorization the channels of perception are located in the first stages, being recognized as one of the different ways through which individuals interact with reality, supporting empiricist theory; while, cognitive styles are located at higher levels, where information is processed and knowledge is constructed, as a result of various experiences or cognitive developments resulting from sociocultural processes, in coherence with constructivist-social theory (Gil, 2014; Villegas and González, 2005; Sánchez-Vidal, 2017; Gavilán et al., 2014).

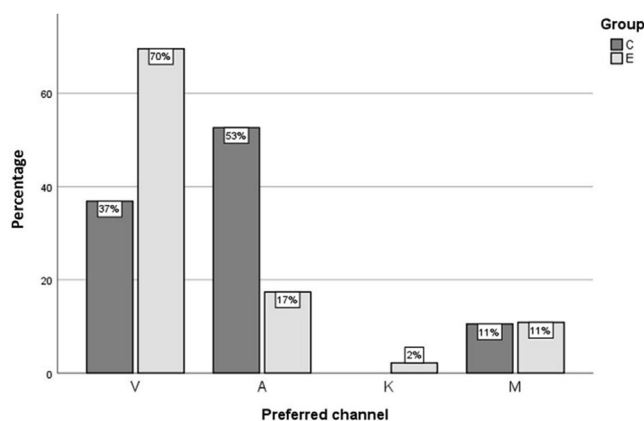


Figure 1. Preferred channels of perception.

Table 1. Spearman's Rho correlation coefficients.

	Coefficient	V	A	K	Ac	Re	T	Pr
V	Coefficient	1.000	-0.739	-0.45	-0.001	.071	0.139	0.085
	Sig (bilateral)		0.000	0.000	0.092	0.572	0.271	0.498
A	Coefficient		1.000	-0.207	-0.034	-0.026	-0.164	-0.124
	Sig (bilateral)			0.098	0.785	0.836	0.192	0.325
K	Coefficient			1.000	0.080	0.003	0.044	-0.020
	Sig (bilateral)				0.528	0.984	0.729	0.876
A c	Coefficient				1.000	-0.211	-0.236	0.224
	Sig (bilateral)					0.091	0.059	0.073
R e	Coefficient					1.000	0.703	0.283
	Sig (bilateral)						0.000	0.022
T e	Coefficient						1.000	0.365
	Sig (bilateral)							0.003
P r	Coefficient							1.000
	Sig (bilateral)							

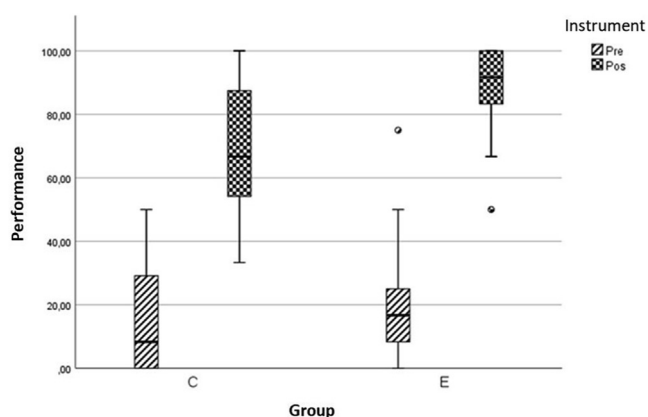


Figure 3. Comparison of the performance of groups C and E in the pre-test and Post-test.

The closeness that exists between channels and styles allows their relationship to be understood from different perspectives, on the one hand, those who consider that they are rivals, that is, two paths that compete to be stimulated to facilitate learning, or seen as followers, in other words, a path that depends on the other to facilitate learning; These two positions are countered with the results obtained in this study described in Table 1, the correlation coefficients deny any type of relationship, whether inverse (opponents) or direct (followers), The results show that the channels of perception and cognitive styles are allies, in other words, two paths that are stimulated together to facilitate learning, a statement that is reinforced by Kelleman and Massey (2013), when understanding that the channel is the first contact with reality, that reality generates information that is processed in the brain, which must then be interpreted configuring cognitive styles that depend on the experiences and challenges in which learning is built; in other words, the channel is a precursor and style is a vehicle.

Table 2. Statistics of the pre-test and post-test.

	Average	Standard deviation	Minimum	Maximum
Pre C	14.4	17.3	0.0	50.0
Pre E	24.1	14.7	0.0	50.0
Pos C	70.6	22.1	33.3	100.0
Pos E	96.0	9.8	66.7	100.0

To establish the associations that exist between perception channels and cognitive styles to facilitate learning, the performance of students has been evaluated after having a training experience, through two didactic strategies, the play strategy with the game tool C=OCarbohydrates and the traditional strategy with the master class.

The comparison of the performance of groups E and C in the Pre-test and Post-test, Figure 3, shows that although the two strategies were effective, in the experimental group there was an increase in the average of 72% while in the control group it was 56% having a greater dispersion in the results, in both cases the experimental group always showed a better performance in the applied tests (Table 2).

Figure 4 shows the percentage performance results with respect to the preferred perception channels. Channel V presents Pre E and Pre C starting groups with similar statistical descriptions, low median values and ranges that do not exceed 50%. After carrying out the didactic strategies, an improvement in the performance of both Pos E and Pos C groups is evident. C, the performance for Pos E being notably better, in contrast, the Pos C group, which was verified with the Kruskal-Wallis test, showing that they are statistically different (Table 3).

Regarding channel A, the Pre C group presented greater dispersion of the data compared to Pre E, a group in which a trend towards low percentage values is evident, after the intervention the results shifted significantly to higher percentages, most of the students in the Pos C group had a performance greater than 60%, while the students in the Pos E group experienced an increase in performance greater than 50%, which shows the efficiency of the play strategy, these results are supported with a statistically significant difference (Table 3).

In the study population, it was only possible to identify a student belonging to group E with a preferred kinesthetic channel, so it was not included in Figure 4, although the results show that the student featured improvement in performance.

For the MC channel, a wide difference was found between the Pre C and Pre E groups, the students belonging to the Pre C group did not demonstrate having previous ideas on the subject, while the Pre E group participants showed better prior knowledge compared to the students classified in the other channels, as demonstrated in Ausubel theory and the subsuming concepts presented by Villarroel and Mazo (2020), and Flores-Espejo (2018). After applying the strategy, a better performance is

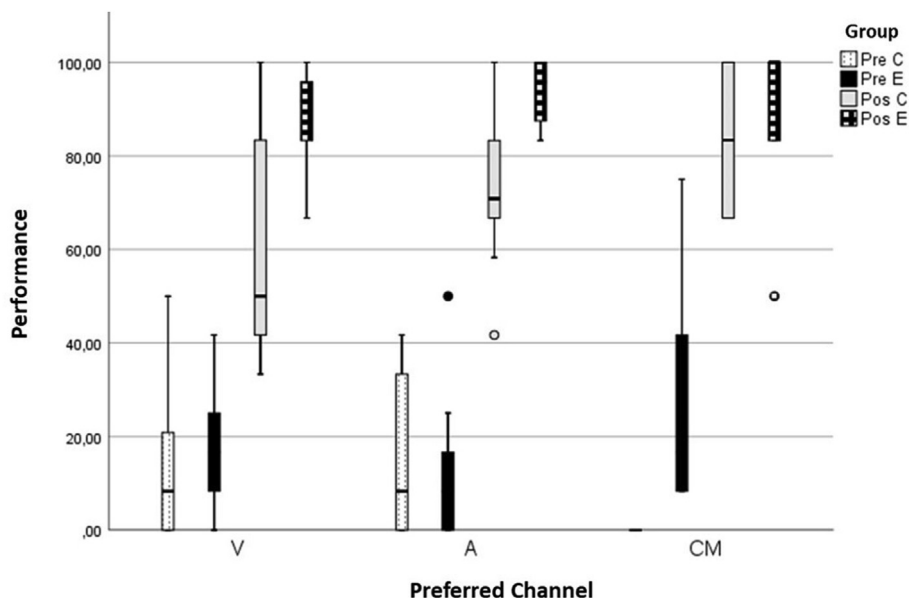


Figure 4. Performance Vs. Channels of perception.

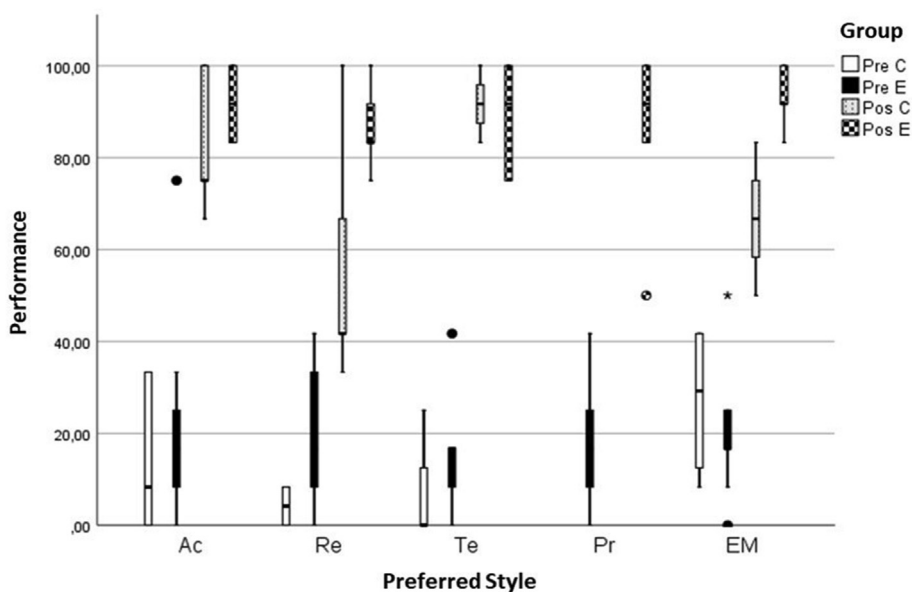


Figure 5. Performance vs. Cognitive Styles.

evident in the students, the Pos E group reaches the best performance centered in percentages greater than 80% and up to 100%, the significant difference between the two groups is demonstrated with the p-value of 0.019 in the Kruskal-Wallis test.

Table 3. Kruskal-Wallis significance coefficients.

	Kruskal-Wallis (p-value)
V	0.022
A	0.018
MS	0.019
RE	0.016
MS	0.014

Figure 5 presents the results of percentage performance with respect to cognitive styles. The Pre E and Pre C groups with AC style have equal ranges, after applying the strategy, the increase in student performance was evident, being more emphasized in the Pos E group who were grouped between 83 and 100%.

Students with Re style, exhibit high performance values in the Pre E group compared to Pre C, after carrying out the didactic strategy, it can be seen that the Pos C group shows the greatest dispersion and the smallest increase in performance, while the Pos E group shows significant progress, managing to locate most of the results above 83%, a difference that was verified with the Kruskal-Wallis p-value (Table 3).

The groups Pre C and Pre E with T style exhibit a low level of previous knowledge in the subject, after the didactic activity, the performance of the two groups was improved achieving high scores. However, the Pos C

group showed better performance compared to the Pos E group, a result that reinforces the conclusions of Montes and Gutiérrez (2017), who claim that theorists build their knowledge based on concepts, which is favored with the traditional didactic strategy.

The Pre C group only had one member, who significantly increased their score after completing the class activity, the Pre E population went from percentages below 40% to scores greater than 80%.

Students with ME have good prior knowledge on the subject, although those from the Pre C group are better, after applying the didactic strategy, a much higher increase is evident for the Pos E group, placing all the results above 80%, while the students in the Pos C group do not exhibit a categorical improvement, showing a great difference in the effect of the strategy on performance, results that are validated with a p-value of 0.014 in the Kruskal- Wallis test.

It is good to highlight that in the evaluation of student performance Vs. channels and styles, some atypical data are observed that represent the performance of students who achieved results outside the trend of the group, for example in channel A and in styles Ac, T and ME students who stood out for their previous knowledge were found, while in channels A and MC and in the Pr style, there were students who did not demonstrate the construction of knowledge around the subject.

5. Conclusions

Channels of perception and cognitive styles contribute to the teaching-learning process independently but in collaborative way, where the channels provide the capture of information and the styles promote interpretation; acting as allies to achieve learning.

People with multiple channels and styles perform better than people with a preferred channel and style, because they have the ability to capture more information and hold more skills to process it.

An efficient teaching strategy is one that promotes a scenario in which channels and styles work together to promote learning and improve academic performance.

The teaching-learning dialogical process requires the design of material and didactic strategies that equitably favor the stimulation of all channels of perception, including the sociocultural component in which the individual contribution is promoted from the characteristics of each of the cognitive styles.

The playful didactic game strategy stimulates all perception channels, promoting the uptake of information that is processed in the brain, facilitating learning, so that proper stimulation of the channels achieves better results. On the other hand, the sociocultural interaction promoted by the game tool favors the foundation of knowledge, through the development of thinking skills that are mediated by cognitive styles; each individual from their characteristics contributes to the collective construction of learning. The above, based on the social and postmodern theories that support the teaching-learning process.

The generation of strategies that manage to stimulate the greatest number of channels and styles, allows a better appropriation of knowledge in Chemistry, for this reason, using strategies focused only on specific channels and styles should be avoided.

As a perspective of the study, it is expected to validate the position sustained by the authors in the research on the concept and the relationship between channels and styles carried out from the theories of learning and knowledge construction, seeking their transcendence, recovering the identity that over time has been mixed. Evaluating different strategies in a larger number of university students from different educational institutions.

The limitations on the study arose because The game C=OCarbohydrates used as an educational strategy was an effective tool for the learning of the subject, as demonstrated in Vera-Monroy et al. (2020), and it is the patrimonial property of the UMB. This is why, in the first instance, the population subject to the study should belong to the institution, once the results are published, agreements will be established to implement in other university populations, thus to generalize the

results. On the other hand, there is no control over the number of individuals that make up each category (channels and styles) since it depends on the characteristics of the individuals that are part of the study, so the percentage assigned to each category cannot be predicted.

Declarations

Author contribution statement

M. C. Gamboa, S. P. Vera-Monroy, A. Mejía-Camacho, W. J. Guerrero-Rueda: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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