Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

*https://doi.org/10.23913/ride.v14i28.1792*

***Scientific articles***

# Aprendizaje de la célula a partir del mapa mental en estudiantes universitarios

## *Learning of the cell from the mental map in university students*

## *Aprendendo a célula a partir do mapa mental em estudantes universitários*

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## Resumen

El presente trabajo de investigación surge a partir del interés por conocer si el mapa mental podría ser una estrategia didáctica para el aprendizaje del tema *célula* en la asignatura de biología. Para ello, es necesario conocer acerca de algunos referentes teóricos acerca de dicha estrategia didáctica. En ese sentido, se trabajó con un grupo de quinto semestre de la Unidad Académica Multidisciplinaria de Ciencias, Educación y Humanidades (UAMCEH) de la Universidad Autónoma de Tamaulipas (UAT) en Tamaulipas, México. A lo largo de la enseñanza educativa se puede observar que prevalece un estilo tradicional, por lo cual se debería utilizar una estrategia que facilite un aprendizaje duradero, claro y comprensible.

**Palabras clave:** mapa mental, aprendizaje, célula, estrategia didáctica.

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## Abstract

The present research work arises from the interest in knowing whether the mental map could be a didactic strategy for learning a topic in the module of biology, specifically the cell. For this, it is necessary to know about some theoretical knowledge about this didactic strategy. In this sense, we worked with a fifth semester group from the Unidad Académica Multidisciplinaria de Ciencias, Educación y Humanidades (UAMCEH) of the Universidad Autónoma de Tamaulipas (UAT) in Tamaulipas, Mexico. Throughout the educational process of learning, mental maps can be seen as a traditional style that prevails, therefore, this strategy should be used that facilitates clear and understandable learning.

**Keywords:** Mind map; learning; cell; didactic strategy.

## Resumo

O presente trabalho de pesquisa surge do interesse em saber se o mapa mental poderia ser uma estratégia didática para o aprendizado do tema célula na disciplina de biologia. Para isso, é necessário conhecer alguns referenciais teóricos sobre a referida estratégia de ensino. Nesse sentido, trabalhamos com uma turma do quinto semestre da Unidade Acadêmica Multidisciplinar de Ciências, Educação e Humanidades (UAMCEH) da Universidade Autônoma de Tamaulipas (UAT) em Tamaulipas, México. Ao longo do ensino educacional pode-se observar que prevalece um estilo tradicional, por isso deve ser utilizada uma estratégia que facilite uma aprendizagem duradoura, clara e compreensível.

**Palavras-chave:** mapa mental, aprendizagem, célula, estratégia de ensino.

**Fecha Recepción:** Junio 2023 **Fecha Aceptación:** Noviembre 2023

# Introduction

The current teaching of biology is influenced by various scientific advances, hence strategies that facilitate effective teaching-learning must be considered. In this educational context, the following question arises: can the mental map be an appropriate didactic strategy for learning the *cell topic* in the subject of biology with fifth semester students of the Multidisciplinary Academic Unit of Sciences, Education and Humanities (UAMCEH) , belonging to the Autonomous University of Tamaulipas?

To try to answer this question, this research will focus on carrying out a bibliographic review on the teaching of biology, its importance and the most common teaching strategies used.

In this regard, it is worth mentioning that most of the existing studies focus on the use of the mental map in basic education, which highlights the importance of this research work, since it will be analyzed whether this pedagogical tool can facilitate the learning of said topic in higher education students.

## Basics theorists

To carry out this research work, a search was carried out information about the referred topic, so different sources were consulted in reliable portals such as Google Academic, Redalyc, Scielo, among others.

## Higher education: brief description in it education system Mexican

The higher educational level in Mexico is made up of that path that follows the baccalaureate and that focuses on the training of human resources in various fields, such as science, technology and the humanities (Morones, sf), for which the institutions of Higher education has the responsibility to provide high-quality education to young people. This implies that it is a system in which individuals must be able to organize themselves effectively to achieve the expectations of the educational institution (Guerrero, 2003, cited by Guerrero and Faro, 2012).

In other words, the role of higher education focuses on fostering creativity and innovation, by creating an educational environment that not only addresses social challenges together with students, but also contributes to training more competent professionals for the future, to which is absolutely necessary for students to be able to apply the knowledge acquired throughout their educational journey in order to achieve meaningful learning, which will be beneficial in their work performance.

## Knowing realities: Mexico in he Program for the International Evaluation of students (PISA)

One of the most used methods to obtain an overview of the knowledge acquired by students in their training process is through standardized tests that provide related results. An example of this is the Program for International Student Assessment (PISA), which, according to the Organization for Economic Cooperation and Development (OECD ) (2018), “ is a triennial survey of 15-year-old students and its evaluation is focuses on three core school areas of reading, mathematics, and science ” (p. 1).

Through this evaluation, it is possible to determine the extent to which students have acquired knowledge and skills that are essential for their participation in society. In this sense, it can be indicated that in the PISA 2018 study, Mexican students obtained scores below the OECD average in reading, mathematics and science. Additionally, around 53% of students in Mexico achieved level 2 or higher in science. This means that students are only able to recognize appropriate explanations for common scientific phenomena and use their knowledge to evaluate, in simple situations, whether a conclusion is valid based on the available data. Likewise, almost no students demonstrated a high level of proficiency in science, reaching level 5 or 6.

From these data, it is evident that the majority of Mexican students fail to obtain satisfactory results in the three areas evaluated: reading, mathematics and science. Therefore, it can be inferred that there are deficiencies in the students' learning process, particularly in the field of science, which could have an impact on the subject of biology. This reality forces the need to implement gradual changes in teaching-learning strategies in order to obtain more favorable results in future evaluations, which must be supported by didactic strategies that promote meaningful learning.

## Teaching biology and its importance

In the teaching-learning process of biology, certain deficiencies stand out, such as the traditional approach to structuring the content. This methodology involves a purely descriptive treatment of the topics, with a predominant participation of the teacher, which encourages rote and repetitive learning. Furthermore, students often have superficial knowledge and have limited opportunities to apply biology concepts and scientific research methods in real learning contexts (Basulto *et al.* , 2017).

In this sense, it is essential that both teachers and students employ strategies that encourage active and dynamic participation to encourage a more creative construction of knowledge. Therefore, it would be appropriate for students not only to acquire knowledge through reading books or lectures, but also to use teaching tools that provide them with more lasting learning.

Additionally, Arteaga and Tapia (2009) argue that in daily practice in classrooms, ideas and approaches very similar to those of past decades persist. They highlight aspects that influence the teaching of biology, including teacher training, their role in the classroom, the student's learning process, and the nature of the knowledge taught. Riveros (2006, cited by Roa, 2020) adds that in the teaching of biology and science, the transmission of knowledge is emphasized, that is, the mere transfer of data.

In my opinion, the learning of this subject is still based on a traditional approach, where the student assumes a passive role and rote learning is encouraged. In this dynamic, the teacher plays the predominant role in communicating the previously established knowledge that students are expected to acquire.

It is also important to highlight that the learning of biology could be affected from previous educational stages, such as high school level. In this regard, Pantoja and Covarrubias (2012) point out that in high school an approach focused on the memorization of data disconnected from everyday life prevails, which leads to knowledge lacking meaning for students on many occasions.

However, this discipline is essential to understand various evolutionary and social phenomena. On this matter, Roa (2020) suggests the following:

> This subject in school emerges due to conditions related to concern for life and social interests regarding it. At the beginning of the last century, attention to life was directed to the child, food, the body, illness, agricultural progress, among others, which in school were already addressed from natural history, physical education, physiology, natural sciences and botany. However, biology is an object of instruction, since it organizes the relationships between such concerns in a different way, since the notion of science converges in it, which gives it a different status in relation to truth and effectiveness (p. 7 ).

According to Báez *et al* . (2012) the purpose of this subject is to train a person with a comprehensive personality and bearer of the highest principles and values, capable of interacting satisfactorily with their environment. From a personal perspective, it is imperative that teachers design activities that arouse the interest and motivation of students during the teaching-learning process in order to generate stimuli that allow them to learn in a meaningful way.

## Strategies most used in teaching biology

According to Tobón (2010, cited in Jiménez and Robles, 2016), teaching strategies are defined as the “set of actions that are projected and implemented in an orderly manner to achieve a certain purpose” (p. 108). These strategies are conceptualized as the procedures (methods, techniques, activities) through which both the teacher and the student consciously organize actions to build and achieve planned and unforeseen goals in the teaching-learning process, adapting accordingly. significant to the needs of the participants (Feo, 2015).

In view of the above, it becomes evident that teachers must strive to adjust their educational practices, using teaching tools that encourage greater active participation of students in any subject they intend to learn.

Regarding teaching-learning strategies in the natural sciences, these can be improved and expanded by incorporating new technologies in the classroom, which could revolutionize the way in which teaching and learning are taught, even in the field of biology. Considering the above, it is relevant to highlight the main teaching strategies identified by Díaz and Hernández (2002, cited by León, 2018), which could strengthen teaching work:

- Summaries: These tools involve the synthesis and abstraction of key information from an oral or written discourse. They serve to highlight fundamental concepts, principles, and the central argument, making it easier to remember and understand information relevant to the content being studied.
- Illustrations: Visual representations of objects or situations related to a specific theory or topic, such as photographs, drawings or dramatizations, allow visual encoding of information, simplifying its understanding and retention.
- Graphic organizers: These visual representations of concepts, explanations, or patterns of information, such as synoptic charts or CQA charts, contribute to better visual and semantic encoding of concepts, propositions, and explanations, contextualizing the relationships between them.
- Graphs: These resources show quantitative relationships between two or more factors or variables through lines, sectors, bars, etc. They help more effectively understand quantitative relationships that would be difficult to understand without visual representations.
- Conceptual maps and networks: These graphic representations schematize knowledge through concepts, propositions and explanations. They are useful for visually and semantically encoding concepts and propositions, as well as for visualizing the relationships between them.
- Textual organizers: These rhetorical structures influence the comprehension and memory of a speech, helping to remember and understand its most important parts.

Now, the teaching strategy addressed in this research corresponds to visual graphic organizers. As mentioned, these make it easier to understand and remember the information learned. In addition, they play a crucial role in organizing the new information that the student is about to acquire, which contributes to giving greater meaning to the topics to be studied.

To do this, of course, the teacher must consider the previous ideas of his students, which will encourage interaction with the new knowledge. Therefore, the teacher's intention should be to generate ideas as they share academic knowledge or school content, particularly in the field of biology, which is part of the world of science (León, 2018).

## Problems in teaching biology

There are various difficulties in the learning process of natural sciences, as Arteaga *et al point out* . (2012). This problem has been the subject of study among researchers concerned with learning and teaching, particularly in the field of biology. Personally, I consider that this topic should be an area of interest for research, since it is essential to understand the difficulties and needs that prevent effective learning of this subject. From this exploration, strategies can be proposed and modified that make it easier for students to acquire knowledge in a more accessible and assimilable way for their cognitive structure.

Furthermore, the problems surrounding the learning of natural sciences continue to be relevant. This is manifested in the lack of interest of the students and, in some cases, the rejection of the subjects in said area, which translates into school failure rates and a shortage of candidates interested in scientific studies (Asencio, 2012, cited by Méndez and Arteaga, 2016).

In addition to the above, traditional teaching, focused solely on the transmission of concepts, limits scientific education to the mere teaching of content. According to Gil and Vilches (2006), scientific literacy should be seen as a form of situated research, which allows students to understand what science truly entails and how it addresses its problems . This enables them to reconstruct the knowledge that is transmitted to them in the science teaching process, which serves to achieve more effective learning. Therefore, it could be argued that biology teaching processes still face numerous challenges, as traditional teaching continues to largely predominate.

Furthermore, according to Tirado and López (1994), the educational system in Mexico shows great weakness, since in the specific case of the teaching of biology it continues to prevail since information is taught in an encyclopedic, isolated and disjointed manner that gives it congruence. . Likewise, most of the time the content exceeds the students' assimilation capacity, which promotes rote learning and a lack of motivation instead of promoting meaningful learning.

Currently, research in the teaching of natural sciences, such as that carried out by Abreu *et al* . (2011) highlight that biology teachers in secondary education lack extensive knowledge regarding innovative and avant-garde teaching strategies, which are essential to motivate students and facilitate effective learning of complex biological content.

Furthermore, Tirado and López (1994) argue that the teaching of biology tends to be encyclopedic, isolated and disarticulated from a general context of integration that provides coherence and meaning. That is, concepts are often presented to be memorized rather than understood, and students are overloaded with excessive information beyond their capacity to assimilate, resulting in overload and promoting a rote approach to learning that leads to to demotivation.

In this context, mind maps stand out for their ability to promote "learning to learn" and "learning to think." These concepts are based on common principles that include comprehensive assimilation, the organization and creation of cognitive structures, the use of previous ideas as a starting point for learning, the importance of key words, the neurological functioning that supports holistic learning, creative expression and the hierarchization of concepts and structures (Ontoria *et al.* , 2011).

Consequently, a rethinking and a breakdown of traditionalist paradigms is required that, instead of helping students and teachers to form knowledge, stagnate them in outdated methods. It is imperative to incorporate strategies that really contribute to the acquisition of knowledge by students, stimulating them to achieve the desired objectives.

## Ausubel's theory of meaningful learning and the map mental

It is vitally important that students acquire knowledge that is lasting and not merely rote. Therefore, it is essential to highlight the importance of meaningful learning, a theory proposed by David P. Ausubel in 1963, which advocates a teaching-learning approach based on discovery that promotes the active participation of the student and the idea that You learn best what you discover for yourself.

This means that the learner should not be a passive recipient, but rather should use previously internalized meanings to understand the meanings that the educational materials offer. In this process, as you progressively differentiate your cognitive structure, you also achieve an integration that allows you to identify similarities and differences, reorganizing your knowledge (Rodríguez, 2011). Meaningful learning, therefore, builds on the student's previous experiences and transforms them into new, more integrated information that, crucially, can be stored in long-term memory, as opposed to rote learning.

In this context, mind maps are presented as an effective tool to promote meaningful learning. According to Díaz and Hernández (2002, cited in Mota and Mota, 2016), these resources are inspired by Ausubel's theory on the hierarchical organization of knowledge. Mind maps can be

used both as teaching strategies by teachers, learning strategies when used by students, and as resources to evaluate declarative knowledge.

With regard to thought processes, mental maps, according to Mota and Mota (2016), help to develop connections with previous ideas, both in their creation before the development of the topic and in their subsequent treatment, as they facilitate the inclusion of concepts, encourage creativity by capturing concepts and improve understanding by establishing relationships between them. In other words, they allow a progressive differentiation between concepts and their integration or assimilation of new relationships between them. Therefore, this strategy promotes the relationship between students' previous ideas and the new information they must learn, which makes it particularly relevant in the context of meaningful learning.

This theory encourages students to build their own knowledge by reflecting on what they already know, instead of limiting themselves to receiving expository classes that could be meaningless for them. Therefore, the teacher should start from students' prior knowledge through a diagnostic assessment and, based on the results, adapt his or her approach to achieve solid learning that takes into account both what students already know and what they already know . that they need to learn.

## Mental maps: strategy for meaningful learning in biology

There are various tools that both students and teachers can use to organize information more clearly and facilitate its assimilation. Among the visual organizers that follow a pattern similar to brain processing, mental maps, conceived by Tony Buzan, stand out. These maps, as pointed out by Núñez *et al* . (2019), are similar to the synapse process, the union of dendrites, in the arrangement of their branches, both in their lines and in their bifurcations. Therefore, this strategy can be highly beneficial in the process of acquiring knowledge, since it establishes a link between the biological part of the student and its graphic representation on paper.

As Ponce (2006) explains, introducing and using the mental mapping technique represents a different way of explaining and presenting the content of the classes, which can capture the attention of students in a new and practical way. In this sense, mental maps are closely related to meaningful learning, since one of their main functions is to integrate and connect new information with previous knowledge structures stored in memory. This type of graphic organizer enhances learning due to its structure that incorporates written and visual elements, which facilitates understanding and the relationship between previous knowledge and the new information that must be assimilated.

Rubio (2012) advocates the inclusion of mental maps in teaching planning as tools and instruments to generate knowledge and promote meaningful learning. Furthermore, he argues that these allow us to identify the cognitive place in which a student is and can bring him closer or support him in the construction of his biological knowledge, since they make use of the cognitive capacity to symbolize ideas, concepts and mental or virtual representations.

On the other hand, Muñoz (2009) highlights that the combination of images and text in mental maps facilitates the storage of information in long-term memory, helps to organize it spatially and temporally, and contributes to the understanding of processes, which supports the construction of your biological knowledge.

## Characteristics and elements to consider when creating a mental map

Mental maps are a tool that condenses into a single sheet the phenomenon to be studied and its multiple connections with related elements, as it covers both those with which it interacts and those that gave rise to the phenomenon. In addition, they incorporate images, colors and keywords that integrate knowledge comprehensive in the brain . Indeed, the brain, as a whole, is activated in various directions: neural connections feed back and intertwine reason and logic, which represents an interconnection between the cerebral hemispheres, uniting the hemisphere of images and creativity with the side in charge of understanding the concept of integration, that is, the right hemisphere with the left, oriented to reasoning.

Now, a quality mental map, according to Buzan (2018, cited by Hernández and Romero, 2016), has three fundamental characteristics:

1. A central image that captures the core of the topic under study. For example, if employs a map mental for to plan a project, you can place he drawing of a folder in the center. Keep in mind that no specific skill is required to create a good map. mental.
2. Thick branches that radiate from the central image. These branches represent the most important related with he affair major and each a should have a Different color. In turn, additional branches—twigs, if any—sprout from the main branches. wants- that constitute he second and third levels, that HE relate with topics complementary.
3. About each branch HE place a alone image or word clue.

On the other hand, it is necessary to know the elements to consider when create a mental map, since this way it will be easier to interpret these organizers graphics ( Buzan, nineteen ninety six, aforementioned by Hernández and Romero , 2016):

- Organization: The information addressed must be intentionally and related with he aim

and idea major for that of this manner I achieved be related to the new ideas up get a complete information.

- Grouping: He map mental HE has to Group and expand through the formation of subcenter that part of he; by it, bliss information has to be interrelated between Yeah.
- Images: The center should be a striking visual image so that it is remembered more easily that words.
- Use of key words: Key notes are more effective than sentences, given that They facilitate remembering.
- Use of colors: It is advisable to color the lines, symbols and images, because this way it is easier to remember them than if they are done in black and white. While further color use more will stimulate the memory, the creativity and the motivation.
- Involve awareness: Participation must be active and conscious. If mind maps become fun and spontaneous, they attract attention, which promotes interest, creativity, the originality and help to the memory.
- Association: All aspects worked on in the graphic organizer they must be related between Yeah, starting off from he center so that ideas are remembered simultaneously.

Therefore, it is essential to take into consideration the characteristics and elements mentioned when creating a mental map, since each of them provides advantages that promote significant learning of the information that the student seeks to internalize. Each element serves a specific purpose, reinforcing the idea that students should be better informed about how to create such a graphic organizer. This would allow them to build mental maps that are truly meaningful and relevant in their process of acquiring knowledge.

## Importance and learning experiences from the mental map

Considering the mental map as a graphic and non-linear representation of a large amount of information and data on a specific topic, as proposed by García Montero and De la Morena (2015), it becomes an ideal tool to promote meaningful learning. This is because it relates prior knowledge to new knowledge, allowing valuable feedback from the student as they reflect on their learning achievements.

Indeed, the mind map is an important tool due to the advantages it presents ( Deladiere *et al* ., 2004), which include the development of autonomy in reflection, the improvement of memory, the ability to address complex situations, the ease of arguing and the construction and mastery of knowledge.

Regarding learning experiences based on the use of mental maps, examples stand out such as the study by Rubio (2012) on the topic “The cell as a unit of living systems” in high school students. This author's qualitative analysis showed that students achieved significant learning and improved their information management by using this graphic tool as a learning strategy.

Furthermore, the project by Calderón and Quesada (2014) that focused on improving reading comprehension in narrative texts through mind maps demonstrated that students showed great interest in learning using this technique. In this sense, the creativity expressed in the “giant mind map” with the use of colors and markers positively fostered the students' interest.

On the other hand, the systematization of the experiences of Spanish students with mental maps, carried out by Antoria (2006, cited by Roig and Araya, 2013), verified that this strategy allows changing the purely rote learning approach and promotes the autonomy of thought. a fundamental aspect in meaningful learning.

In summary, according to Sambrano and Steiner (2000), it can be said that traditional learning is based on mechanical repetitions. However, the use of mind maps establishes meaningful associative connections that facilitate faster understanding and more effective retention of information, as well as the ability to establish new associations that will serve as a basis for acquiring knowledge more efficiently. Therefore, mind maps have demonstrated favorable results as a learning strategy, suggesting that they are one of the many innovative tools that can enrich education and move away from the traditional approach.

## Study methodology and results

Based on the above, a study was carried out with the purpose of determining whether the incorporation of mental maps benefits the acquisition of significant knowledge on the subject of *cells* in the context of the biology subject. This study was carried out with fifth semester students of the UAMCEH-UAT.

The applied methodology will play a crucial role in the research process, since through the instruments used the necessary information will be collected for subsequent analysis and, in this way, the question raised can be addressed and the proposed hypothesis verified, which maintains that the incorporation of mental maps in teaching the topic of *cells* in fifth semester students of higher education in the field of biology promotes meaningful learning.

## Methodological strategy

This study was based on a mixed method approach, which combines qualitative and quantitative aspects. This, according to Cedeño (2012), implies the integration of both methods "in a single study with the purpose of obtaining a photograph more complete of the phenomenon" (p. 19). Using this approach, we sought to understand concrete data expressed in percentages and, at the same time, capture the underlying characteristics that enrich our understanding of reality.

This approach was materialized through an evaluation consisting of eleven closed questions, designed to evaluate various aspects of the mental map, such as its ability to facilitate meaningful learning and its usefulness in the organization of notes, among others. In addition, the knowledge acquired was evaluated both through the implementation of mental maps by the students and through three exploratory questions related to the concepts learned in class.

## Description of the study sample

The unit of analysis of this study was the UAMCEH, while the target research sample—defined by Hernández *et al* . (2014) as "a subgroup of the population from which data is collected and must be representative" (p. 173)—was composed of eleven students of both genders, aged between 19 and 25 years, who are in the fifth period of the Biology subject.

The sampling method used in this research was non-probabilistic for convenience. This is because the selection of students was not based on probability, but on the specific characteristics of the research and the availability to collect information. As mentioned in the work of Hernández *et al* . (2014), this type of sampling is a "selection procedure guided by the characteristics of the research, rather than by a statistical criterion of generalization" (p. 189). Non-probabilistic samples are made up of available cases that can be accessed ( Battaglia , 2008, cited by Hernández *et al* ., 2014).

## Data collection instrument

A questionnaire was used as a data collection instrument in this study, which was based on the Likert scale to express the degree of agreement or disagreement with each item presented. In addition, the questionnaire consisted of six open questions, two questions with "Yes" or "No" response options, with space to explain the choice. The purpose of this instrument was to evaluate the students' assessment after carrying out the intervention in the classroom, that is, after creating a mental map to evaluate the teaching strategy in relation to their learning on the topic of the cell.

It was also intended to determine whether they had actually acquired knowledge through this strategy. The questionnaire was distributed in printed format to be completed by study participants.

### Information collection procedure

Regarding data collection in the classroom, it began with a presentation of the *cell topic* , during which the students' previous knowledge was recovered through oral and voluntary questions. Then, students were asked to create a mind map based on what was taught in class. Finally, they were given the questionnaire to answer.

As previously explained, this questionnaire contained statements related to the use of the mind map, as well as three open questions to evaluate whether they considered the mind map to be an appropriate tool for the study of biology, if they intended to use it in their daily lives. or in other subjects, and three questions about the knowledge acquired through the mental map.

## Results

According to the results obtained through the instrument for assessing the mental map strategy in cell learning, it can be stated that the majority of participating students (46%) use the mental map as a tool to organize notes and Learning notes related to biology topics. Furthermore, 55% strongly agreed that the mind map makes it easier to organize and represent information about the cell for easy recall. These findings correlate with the idea presented by Sambrano and Steiner (2000), who point out that these resources are useful for taking notes, planning, condensing information and organizing, especially when keywords are used as part of this tool, which helps to remember the material more effectively.

In relation to the students' perception of the use of the mental map as a knowledge acquisition tool, 37% totally agreed with this idea, which coincides with what was mentioned by Molina and Martínez (2016, cited by *et al* ., 2019), who highlight that these learning tools are effective in achieving meaningful learning. This happens because the graphic representation of mental maps allows students to understand and assimilate the content in a simpler and more understandable way, which promotes lasting learning based on the relationship between the student's scaffolding and their previous knowledge accumulated throughout the course. their education.

Regarding the structure of mind maps, 64% of respondents indicated that they knew elements such as keywords, images and lines that connect ideas, knowledge that is essential to simplify the proper creation of mind maps and , therefore, more effective learning.

On the other hand, 55% of students agree that mind maps can contribute to clearer and more understandable knowledge acquisition. In this sense, and thanks to the organization of information in a graphic representation and a clear structure, as well as the sequencing of central and secondary ideas, mental maps can facilitate the understanding of specific topics (Carrasco, 2004, cited by Roig and Araya, 2013).

In addition to facilitating the conception of knowledge in a simple way, the mind map also promotes creativity and dynamic learning (Roig and Araya, 2013), as perceived by 73% of students. This is due to its ability to balance the activity of the two hemispheres of the brain, since the right hemisphere is related to imagination, creativity and the general vision of things, while the left hemisphere focuses on language, rationality. and logic. In this way, the mental map enables the autonomous construction of knowledge, as indicated by 37% of those surveyed, since they can regulate their own learning through reflection on their knowledge and their initiative in their training process.

On the other hand, regarding the usefulness of the mental map for learning biology topics, specifically about the cell, 46% of students agreed with its effectiveness, which supports the successful implementation of this strategy. Furthermore, Muñoz (2009, cited by Rubio, 2012) suggests that images should occupy a central place in biological education, since they allow the long-term storage of information, the spatial organization of information and the understanding of processes. Likewise, they facilitate the creation of visual mental images that help understand more complex and deeper phenomena.

In accordance with the above, 91% of students consider that the mind map is a relevant option for studying biology topics. This shows that the mental map could be applied not only to the study of the cell, but also to other topics in this discipline. Furthermore, mental maps are a versatile strategy that improves study, learning and thinking skills, and adapts to both individual and collaborative construction of knowledge (Buzán and Buzan , 1996, cited by Rubio, 2012).

Now, despite its versatility, 54% of students would not use the mind map to plan daily activities, as they believe it is unnecessary for simple tasks, which is why they prefer to use a checklist. However, Jaschke (2017) maintains that mental maps are also useful for organizing aspects of personal life, free time, and social interactions. In addition, Sambrano and Steiner (2000) mention that they are valuable as personal agendas, to plan the day, organize vacations, make purchasing, selling and travel decisions. In other words, mind maps have multiple applications not only in education, but also in daily life, including decision making and other areas.

Even so, in terms of education, 91% of students expressed their willingness to use the mind map for learning in other subjects, such as chemistry, interest and motivation in learning, Spanish, mathematics, geography, and design and adaptation. of the curriculum. This diversity of interests underscores the versatility of mind maps as learning tools. In this regard, several studies have explored the application of mental maps in different subjects, such as “Introduction of mental maps in mathematics teaching” (Ponce, 2006), “Mental and conceptual maps as strategies to promote reading comprehension in schoolchildren of primary education” (Guzmán, 2012), and “Mental maps in the learning of geography” (Tapia, sf), among others.

Now, after assimilating the information in class and creating a mental map, the students were asked to answer three questions about the acquisition of knowledge, which were formulated with the purpose of evaluating whether they had managed to learn about a specific topic in the biology subject, in this case, about the cell. In response to the question “What is the cell?”, the eleven students agreed that it is the fundamental microscopic unit that performs various functions. In fact, the majority provided detailed answers, indicating a positive outcome.

Next, they were asked to name three cell structures and their functions. Five students responded completely, one did not provide a response, two students gave incorrect responses, and three provided partial responses. These results suggest that some students experienced difficulties in fully internalizing knowledge using the mind map strategy. However, the majority demonstrated a positive impact, suggesting the need for more appropriate implementation of this tool to maximize its effectiveness. Finally, they were asked to describe the cell's overall classification, and all of them answered correctly.

In summary, the previous findings suggest that the mental map could be an effective strategy for learning about the cell in the subject of biology. However, work needs to be done in cases where students still encounter difficulties when using this tool, which could be achieved through a more detailed explanation of the structure, application and advantages of mind maps, among other aspects.

# Discussion

At the conclusion of this research, the objective has been achieved by analyzing the results obtained from the applied instrument and the reviewed literature. Furthermore, the initial question posed has been answered: “Is the mental map a relevant didactic strategy for learning the *cell topic* in the biology subject with fifth semester students at the UAMCEH?” The answer is affirmative, since it has been proven that this resource is favorable and appropriate to improve students' understanding. This agrees with what was explained by Molina and Martínez (2016, cited by Núñez *et al* . 2019), who suggest that these learning tools are effective in achieving the desired meaningful learning.

Another experience that coincides with the findings of this study is that developed by Ontoria *et al* . (2006), who systematized the experiences of higher-level students in relation to the use of mental maps and managed to verify that this strategy promotes understanding, assimilation of content, the development of autonomy of thought and the willingness to change the way of learning. These last two aspects are particularly relevant, since they are closely related to meaningful learning, since students construct their own ideas based on the relationship between previous and new knowledge.

Therefore, it can be concluded that, according to other authors and based on the results of this study, the applicability of mental maps allows the organization of ideas for the acquisition of knowledge in a clear and understandable way, which promotes autonomy. in the construction of knowledge and the development of meaningful learning.

However, it is important to point out some methodological limitations of this study, such as the lack of the students' perspective, which could enrich the interpretation of the results. Furthermore, the scarcity of previous research on this topic, since most studies focus on basic education, despite the multiple advantages that this learning strategy offers.

Ultimately, this study supports the idea that mind maps can be a valuable tool in facilitating meaningful learning, encouraging students to go beyond the exclusive acquisition of knowledge and question the traditional teaching paradigm.

## Conclusion

In conclusion, this research highlights the need to transform educational practices in science teaching, particularly in biology. These changes must address both teachers and students and must encompass all educational levels, rather than relying exclusively on a teaching strategy focused on traditional methods that have prevailed for many years. It is evident from the literature review that research on mind maps has focused primarily on basic education. Therefore, it is crucial to consider university students as individuals with similar interests, including the need for engaging, creative, dynamic and meaningful learning, rather than relying on a traditional, rote approach.

Furthermore, it should be noted that there are numerous teaching-learning strategies available, so the implementation of graphic strategies such as mind maps represents only one valuable option. These maps can inspire students to participate more actively in the process of acquiring knowledge, which would allow them to assimilate information in a fluid, simple and clear way. However, it is the teacher's responsibility to consider the particularities of the students and reflect on their own pedagogical practice to ensure that the impartation of knowledge is effective.

Likewise, it is worth highlighting that mental maps can be applied in various areas and situations, since in the educational environment they play a fundamental role by promoting creativity and stimulating the brain by involving both cerebral hemispheres, which in turn stimulates the learning process. In fact, these tools are easy to use, since combining images and words promotes imagination and simplifies the assimilation of information.

In summary, mind maps offer numerous advantages, but they are not intended to be the only solution to all educational challenges. Both students and teachers must be aware of the diversity of tools available to promote meaningful learning and adapt to the specific needs of each educational context.

## Future lines of research

Some interesting aspects that could be examined in future work include the evaluation of the mental maps created by the students. For this, the Suárez and García instrument, presented in Sambrano and Steiner (2000), could be used, which evaluates various aspects such as representativeness, analysis and synthesis, creativity, the generation of original ideas and the visual presentation of mind maps, including the use of colors and symbols. This approach would allow for a deeper understanding of the effectiveness of the learning strategy from the student's perspective. Additionally, note that creating mind maps could also promote cooperative learning,

allowing students to collaborate with each other to construct knowledge from diverse ideas and perspectives.

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Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467