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

https://doi.org/10.23913/ride.v10i19.573

Artículos Científicos

Modelo pedagógico de integración sinérgica para la enseñanza de las ciencias experimentales

Pedagogical Model of Synergistic Integration for the Teaching of Experimental Sciences

Modelo pedagógico de integração sinérgica para o ensino de ciências experimentais

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Resumen

En un mundo cada vez más globalizado, con un mayor número de avances científicos y tecnológicos, se requiere que los estudiantes tengan una formación científica que les permita estar a la vanguardia de las necesidades actuales. Por ende, es necesario dejar de lado los paradigmas tradicionales y posicionar en su lugar modelos que integren diversos enfoques que se ajusten a la complejidad del contexto. El objetivo de este estudio es, en primer lugar, revisar modelos pedagógicos que contribuyan a mejorar el aprendizaje de las asignaturas que conforman el área de ciencias experimentales, y en segundo, proponer un modelo pedagógico de integración sinérgica que permita promover un proceso de enseñanza-aprendizaje que sea consistente con los requerimientos de la sociedad actual y con ello propiciar el interés de los estudiantes hacia el estudio de estas áreas.

Para alcanzar lo anterior se utilizó la metodología de sistemas suaves de Checkland, que estudia a los sistemas flexibles que poseen un alto componente social, cultural y político, como lo es el ámbito educativo, y obtener así una propuesta cimentada en los modelos constructivista, social-cognitivo, pensamiento complejo y ecológico contextual con un enfoque eco-ciber-sistémico-transdisciplinario. Esta investigación es parte de una primera etapa que incluye la visión holística de la enseñanza de las ciencias experimentales. Posteriormente se realizará un estudio de caso en el Colegio de Ciencias y Humanidades plantel Vallejo.

Palabras clave: aprendizaje, ciencias, complejidad, proceso de enseñanza.

Abstract

In an increasingly globalized world, with greater number of scientific and technological advances, students require to have a scientific background that allows them to be at the forefront of current needs. Therefore, it is necessary to replace traditional paradigms by models that integrate different approaches that fit the complexity of the context. The objective of this study is, first, to review pedagogical models that contribute to improving the learning of the subjects that make up the area of experimental sciences, and second, to propose a pedagogical model of synergistic integration that allows to promote a teaching-learning process that is consistent to the requirements of today's society and thereby foster the interest of students towards the study of these areas.

For this, the Checkland soft systems methodology was used to study flexible systems that have a high social, cultural and political component, such as the educational field, thus obtaining a model based on the constructivist, social-cognitive, complex thinking models and ecological context with an eco-cyber-systemic-transdisciplinary approach. This research is part of a first stage that includes the holistic vision of the teaching of experimental sciences. Later a case study will be carried out at the Colegio de Ciencias y Humanidades Campus Vallejo.

Keywords: learning, science, complexity, teaching process.

Resumo

Em um mundo cada vez mais globalizado, com um número maior de avanços científicos e tecnológicos, os alunos precisam ter uma formação científica que lhes permita estar na vanguarda das necessidades atuais. Portanto, é necessário deixar de lado paradigmas tradicionais e modelos de posição que integram diferentes abordagens que se encaixam na complexidade do contexto. O objetivo deste estudo é, em primeiro lugar, revisar modelos pedagógicos que contribuam para melhorar a aprendizagem das disciplinas que compõem a área das ciências experimentais e, em segundo lugar, propor um modelo pedagógico de integração sinérgica que permita promover um processo de ensino. aprendizado que seja consistente com os requisitos da sociedade atual e, assim, fomente o interesse dos alunos pelo estudo dessas áreas.

Para tanto, foi utilizada a metodologia de sistemas flexíveis Checkland, que estuda sistemas flexíveis com alto componente social, cultural e político, como o campo educacional, e obtém, assim, uma proposta baseada nos modelos sociais construtivistas. pensamento contextual cognitivo, complexo e ecológico, com uma abordagem ecossistêmica-sistêmica-transdisciplinar. Esta pesquisa faz parte de uma primeira etapa que inclui a visão holística do ensino experimental de ciências. Posteriormente, um estudo de caso será realizado na Escola de Ciências e Humanidades Vallejo.

Palavras-chave: aprendizagem, ciência, complexidade, processo de ensino.

Fecha Recepción: Julio 2019 **Fecha Aceptación:** Diciembre 2019

Introduction

Because in recent years various investigations have been carried out to know the factors that have caused a crisis in scientific education and that it has been found that, although the origins of the distance of science and technology in Mexico are diverse, one of the most relevant elements is focused on the teaching of basic education (Flores, 2012), this study focuses on the teaching and learning of the subjects that make up the area of experimental sciences (ACE).

The teaching of science in the educational field presents problems due to the use of traditional pedagogical strategies that do not encourage the understanding of scientific and technological issues (López, 2015), and thus cause a crisis by not being able to respond to new social challenges. Since, as is well known, there is a difference between the teaching of science in the classroom and what the student really needs to know for decision-making, which has led to fragmented or decontextualized knowledge and, consequently, a vision little globalized As a result, high levels of illiteracy of science have been obtained in the western world (Matthews, 2017).

The above is stated in the report of the International Program for the Evaluation of Students [PISA] (Organization for Economic Cooperation and Development [OECD], 2015), where the results show that only 8% of students in the countries that make up The OECD reaches the highest levels of competence in relation to science. In Mexico, this reality is no different, since only 0.1% of the participants achieve the same levels, and this has not changed since 2006, which means that 48% of young people in Mexico do not have the minimum scientific knowledge that allow you to participate in a complex society (National Institute for the Evaluation of Education [INEE], 2016).

Thus, it is clear that it is necessary to modify the learning models of science and propose active strategies (Arteaga, Armada and Del Sol, 2016) that develop cognitive, instrumental and transversal skills in students, in order to extend learning to its surroundings (Drăghicescu, Petrescua, Cristeab, Gorghiuc and Gorghiuc, 2014). However, most educational centers have not detached themselves from traditional education (Pantoja y Covarrubias, 2013).

Along the same lines, Reimers and Chung (2016) state that there must be a pedagogical and valuation change with the objective of promoting a real-world self-directed learning; however, as already mentioned, many educational spaces still implement traditional teaching systems; systems that have proven not to allow the development of scientific competences demanded in the current context in most people (Sanmartí and Márquez, 2017).

Undoubtedly, in an increasingly globalized world with new demands to meet, it is necessary to train individuals with knowledge, skills, attitudes and values that allow them to understand and transform their environment. At the same time, scientific training is convenient not only because it depends on whether or not students are attracted to careers related to science; For many students it will be the last opportunity to acquire the necessary culture in order to understand the scientific and technological development that unfolds around them, which will also allow them to exercise as a critical and responsible citizen of the 21st century (Secretariat of Public Education [SEP] , 2017).

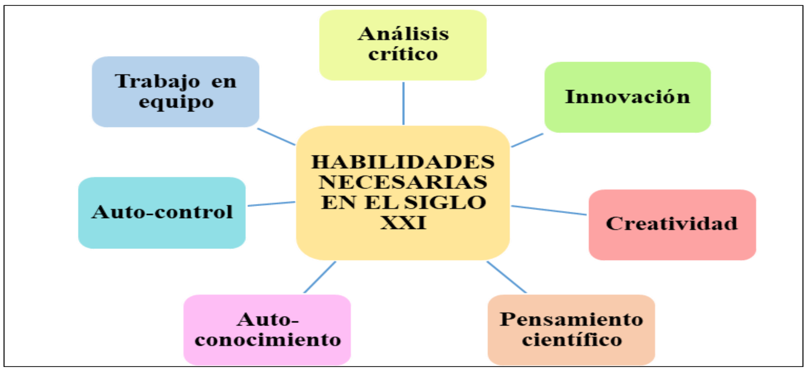
Based on the above assumptions, the objective of this study is to review pedagogical models that contribute to improving the learning of the subjects that make up the ACE at the upper middle level, particularly of the College of Sciences and Humanities (CCH), and thus propose a pedagogical model of synergistic integration (MPIS) that allows promoting a teaching-learning process that is consistent with the requirements of today's society and, in addition, is capable of fostering the interest of students towards the study of these areas.

Skills required in the knowledge society

Education, in general terms, needs to develop the skills required by the citizen of the 21st century; among which scientific thinking and critical analysis stand out. This in order to provide the basis for individuals to participate in subjects related to science and technology in an educated manner, since if it is alien to this type of knowledge, they will be unable to intervene and, consequently, will be in need of delegate responsibility to others.

With respect to the above, Figure 1 shows the skills that need to be promoted in the student. It should be noted that these are not new, and were probably even requested or used in the past; However, unlike previous times, they are not focused on a select group, but are required for the entire population (Reimers y Chung, 2016).

Figura 1. Habilidades necesarias para la población en el siglo XXI



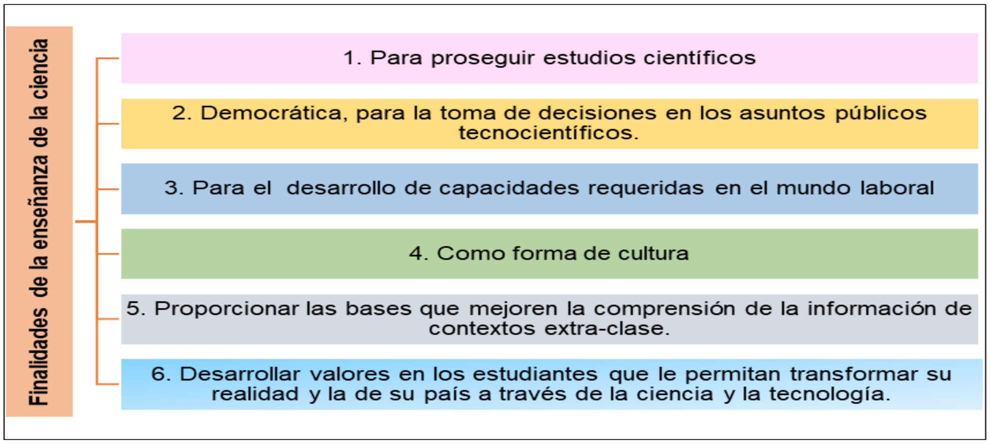
Fuente: Elaboración propia con base en Reimers y Chung (2016)

Purposes of science education

The teaching of science has had various purposes throughout history. At the beginning it was studied because it was a requirement to enter higher education. Subsequently, his intention was the training of scientists in order to meet the demands of the technological developments of the time (De Freitas Dias and Alves, 2010). In recent years, this perspective was transformed, given that greater importance was given to teaching related to everyday life contexts that included social and technological issues; in the development of a basic scientific education that allows to train active and responsible citizens (Adúriz et. al, 2011).

At present, the study of the subjects that make up the ACE has the responsibility of promoting knowledge in the students that respond to the complex processes and procedures of the real world, therefore, today, the teaching of science at the level upper middle has numerous purposes to meet the needs of today's society (see figure 2).

Figura 2. Los principales propósitos de le enseñanza de la ciencia



Fuente: Elaboración propia con base en Arteaga *et al.* (2016)

It should be added that the objectives of teaching science in pre-university fields must correspond to the personal, local and global environment of the student, as expressed in Figure 3. The importance of this lies in the student's understanding of their own culture and thereby developing a critical, reflective and proactive thought.

Figura 3. Finalidades de la enseñanza de la ciencia en el contexto personal, local y global

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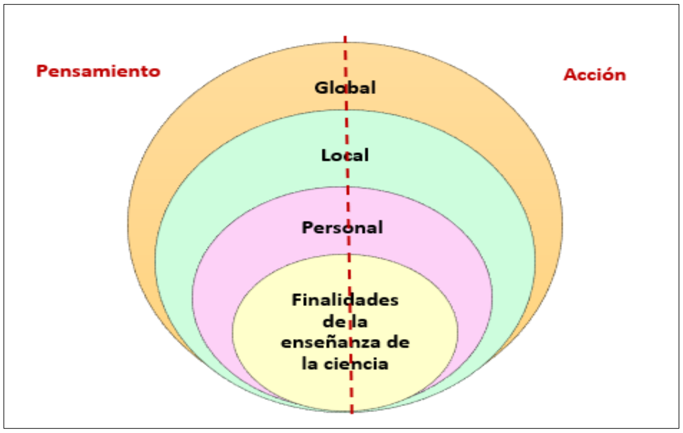
ISSN 2007 - 7467



Fuente: Elaboración propia

Pedagogical model

A pedagogical model is the schematic, systematic and consciously simplified representation of the set of relationships that describe a phenomenon in order to facilitate its understanding (Abarca, 2007). It is also a theoretical scheme that details what should be taught, what should the student learn, how the student learns, the teaching methodology, the assessment of knowledge, defines the role of teachers and students, as well as the interactions between them (Bournissen, 2014, p. 248).

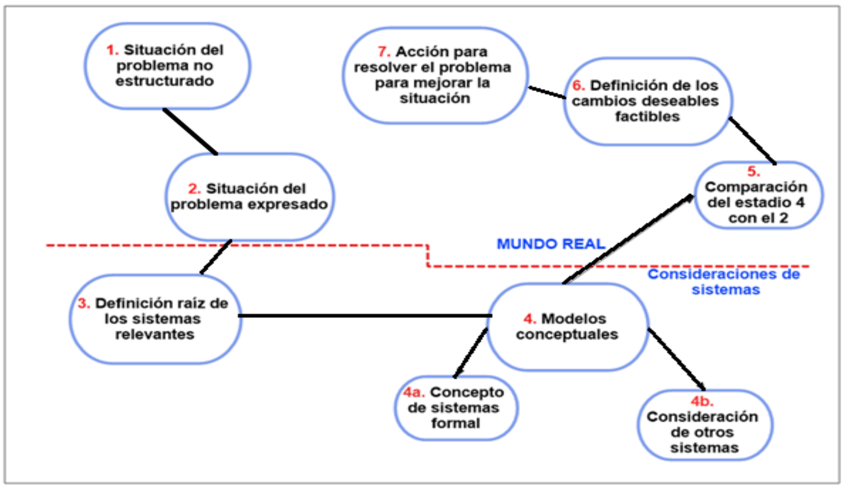
Pedagogical models are composed of psychological aspects of the learning process, sociological, communicative, ecological or gnoseological (Ortiz, 2011). On the basis of the ideas set forth above, it can be said that a pedagogical model is an integral and integrative approach referring to a certain phenomenon from a theoretical and practical point of view (Vergara and Accounts, 2015, p. 915).

On the other hand, a pedagogical model "establishes the parameters to analyze the practices of the pedagogical act that becomes a permanent process of social construction and a daily investigative aspect that requires information gathering and systematization for subsequent analysis and interpretation" (Live , 2016, p. 42). In the same direction, pedagogical models can promote changes in class structure, content, methods, objectives, activities and evaluation. At the same time, they are a hidden guide towards the development of training tasks (García y Buitrago, 2017).

Methodology

This study is focused on the Checkland soft systems methodology (see figure 4). This is based on using parts of the real world as systems in order to find a solution to problematic situations in a flexible way, because each context is unique and demands a methodology that fits the characteristics and needs of each situation, and that in reality the same event is not repeated twice in the same way (Checkland, 2013).

Figura 4. Metodología para sistemas blandos



Fuente: Checkland y Scholes (1990)

The above scheme is fragmented into two parts, integrated by phases 1, 2, 5, 6 and 7, which are immersed in the real world. Phases 3 and 4 are included in systemic thinking. The following briefly defines what each part of the Checkland methodology consisted of.

1) Situation of the unstructured problem: This research focuses on the CCH campus Vallejo, therefore, in this stage information was collected through a documentary investigation and the application of a survey of 24 professors and 92 students of said institution, about what are the difficulties of teaching experimental sciences.

2) Status of the problem expressed: With respect to the information collected in step number one, the scheme of the main difficulties that exist in the teaching of sciences was constructed.

3) Root definition: It is based on six CATWOE factors that refer to customers, actors, transformation process, weltanschauung (world view), system owner and environment.

4) Conceptual models: Starting from the root definition, it is exposed how science should be taught.

5) Comparison of stage four with two: Based on the information on how science should be taught and what its aims are at the upper middle level, the pedagogical models were reviewed, which, due to their theoretical or practical characteristics, could improve The teaching of science.
6) Definition of the desirable changes: In this stage the particularities of the pedagogical models that were examined in the previous step were chosen based on what is expected as a process and product of the teaching of science.
7) Action to solve the problem: In this step the integrated pedagogical model was designed that contemplates the chosen characteristics of the pedagogical models reviewed in the previous phase.

With regard to the unstructured situation of the problem, it is necessary to specify that the pedagogical model proposed by the CCH has a constructivist approach, of a pro-therapeutic nature and of a basic culture. It is oriented to the intellectual and social formation of its students, considered subjects of culture and their own education. It also prioritizes the learning to be achieved by students through conceptual, procedural and attitudinal contents, in order to explain natural phenomena.

Unfortunately, ACE matters occupy the second place in attrition and failure rate in the CCH; They are only surpassed by the subjects that make up the area of mathematics.

Table 1 shows the results of the documentary research, regarding the problems that exist in the teaching of the ACE subjects.

Tabla 1. Dificultades en la enseñanza de las ciencias experimentales

Autor	**Dificultades en la enseñanza de las ciencias experimentales**

Adúriz *et al.* (2011)	El uso de libros en las clases, cuya función principal es leer su contenido escrito.
Dávila, Borrachero, Cañada, Martínez y Sánchez (2015)	Impartir contenidos científicos que propician mayoritariamente emociones negativas.
Furman, Luzuriaga, Taylor, Anauati y Podestá (2018)	Repetición mecánica y memorización de hechos, definiciones y algoritmos (p. 83).
Garzón y Pérez (2015)	No se considera el lenguaje como medio de comunicación de los saberes, los cuales son alejados del contexto social y cultural de los estudiantes.
González (2015)	Carencia de los conocimientos a enseñar y el desconocimiento de cómo enseñarlos (p. 18).
Martínez y Riveros (2019)	Experimentos aislados y descontextualizados.
Pantoja y Covarrubias (2013)	Predomina la transmisión de los conocimientos.
Torres (1975; citado en Ortega y Gil, 2018), Solbes *et al*. (2007; citados en Ortega y Gil, 2018) y Vílchez *et al*. (2015; citados en Ortega y Gil, 2018)	La aplicación de evaluaciones cuantitativas dirigidos a calificar el contenido memorizado y no otras formas de aprendizaje.
Padilla, Brooks, Jiménez y Torres (2016).	Desarticulación del currículo entre las asignaturas que conforman el del área de ciencias (p. 17).
López (2015)	Desafíos del entorno en aspectos contextuales en relación con las características de los estudiantes, el medio educativo, los fines, propósitos y valores de la enseñanza (p. 76).
Macedo (2016)	Una enseñanza basada en conocimientos cerrados, acabados, sin relación entre ellos y su realidad solo es en el ámbito educativo.
SEP (2017)	La falta de interés, e incluso rechazo hacia el estudio de las ciencias, asociado al fracaso escolar.

Fuente: Elaboración propia

Likewise, based on the information obtained from Table 1, an evaluation instrument (survey) was developed in order to know the perception of the actors in the teaching-learning process, in particular with regard to the difficulties presented by the subjects of the ACE in four

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

aspects: 1) content, 2) activities, 3) evaluation and 4) attitudes; for which a consecutive non-probabilistic sampling technique was developed for 24 professors in the experimental area (8 chemistry teachers, 10 physics teachers and 6 biology teachers) and 92 students between the ages of 14 and 18 (44 women and 48 men) The responses obtained were synthesized and are shown in table 2.

Tabla 2. Percepción de los profesores y de los alumnos encuestados del CCH plantel Vallejo sobre las dificultades de la enseñanza de las materias de ciencias experimentales

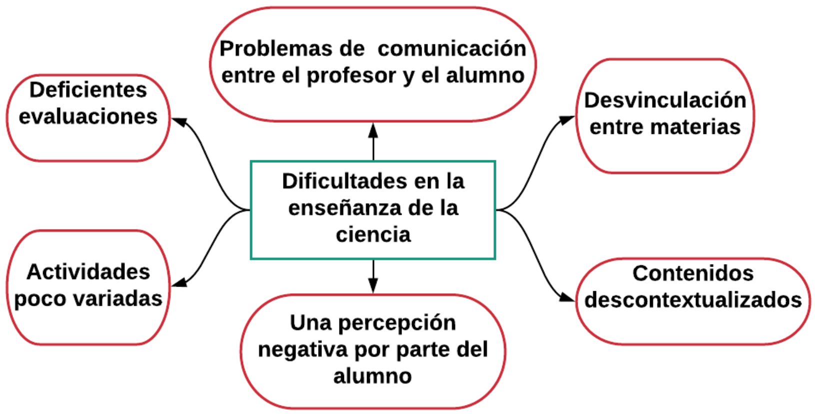
Criterios	**Profesores**	**Alumnos**

Contenido	- Dificultades para contextualizar algunos contenidos del programa de estudio. - Hay que abordar demasiados contenidos en un lapso muy corto. - Es complicado relacionar los aprendizajes con el resto de las asignaturas que integran el ACE, debido a las características de cada programa de estudio.	- Algunos temas no tienen utilidad en el entorno personal. - Las clases de ciencias experimentales son interesantes, no obstante, son difíciles por el uso de las matemáticas, las unidades y los conceptos que se deben aplicar.
Actividades	- La falta de materiales complica la realización de actividades experimentales. - Por cuestiones de seguridad, se evitan hacer experimentos o solo se hacen algunos muy sencillos. - Las actividades deben ser simples para que las terminen en clase, de lo contrario no las hacen de tarea.	- Se realizan pocos experimentos en clase. - Los maestros principalmente hacen experimentos demostrativos y no entiendo cuál es propósito de la actividad. - Los profesores son poco dinámicos, ya que las actividades se centran en leer y en exponer.
Evaluación	- Por cuestiones de tiempo solo se promueven evaluaciones cuantitativas. - En las evaluaciones diagnósticas se observa que existen errores conceptuales por parte de los alumnos.	- Las evaluaciones no son acordes con lo que el maestro enseñó en clase. - Los maestros son los únicos que evalúan. - Desconocen la forma de evaluación del curso.
Actitud	- Los alumnos no les interesan las clases de ciencias, existe una falta de compromiso por sus estudios. - Los estudiantes tienen una predisposición negativa hacia las materias de ciencias experimentales.	- Los profesores se enojan si se les preguntan las dudas. - Los profesores no les interesan si entendemos, sino que entreguemos los trabajos.

Fuente: Elaboración propia

From a more general perspective, the problematic situations that had the highest incidence were identified, thus obtaining figure 5.

Figura 5. Esquema de la situación problemática de la enseñanza de las ciencias



Fuente: Elaboración propia

Based on the above, the root definition for this system is the design of a pedagogical model that links emerging rational knowledge with the emotional dimension, considering the exogenous and endogenous factors of the context, in order to promote the inclusion of scientific thinking. systemic, critical, purposeful and active and thus achieve significant learning in the student to implement them in his personal life and in the local and global environments. It should be noted that the root definition was based on the CATWOE described below:

- Client (C): The main beneficiary is the student. Indirect beneficiaries will be teachers, parents, the CCH community and society.
- Actors (A): Peers, teacher, parents, school, community and society.
- Transformation (T): Identify the inputs, the process and the output, which are shown in table 3.

Tabla 3. Proceso de transformación

Entrada	Proceso	Salida
Una enseñanza basada en conocimientos cerrados, aislados,	Una propuesta pedagógica híbrida en la que se integren las fortalezas de cada modelo, con la finalidad de abarcar un mayor	Una enseñanza contextualizada, transdisciplinaria,

descontextualizados y fragmentados.	número de factores que afectan la enseñanza y el aprendizaje en ciencias experimentales.	vivencial y práctica.

Fuente: Elaboración propia

- Weltanschauung (W): Allow to promote a teaching-learning process that is consistent with the requirements of today's society and thereby encourage students' interest in studying ACE.
- System owner (O): CCH teachers and authorities.
- Environment (E): It is the National Autonomous University of Mexico (UNAM), according to its guidelines, cultural, social and political context that surround the CCH.

Starting from the root definition, it was considered how science should be taught to improve the results obtained so far (see table 4).

Tabla 4. Como se debería de enseñar la ciencia

Autor	**Cómo se debería de enseñar la ciencia**
Torres (2010)	Los docentes requieren una didáctica coherente y adecuada al actual contexto sociocultural (p. 140)
Dávila *et al*. (2015)	El docente debe favorecer y promover emociones positivas para inducir y estimular el aprendizaje.
Adúriz *et al*. (2011)	Planificar una enseñanza de las ciencias en la que las ideas, los procesos, las capacidades y las actitudes se complejizan, y se

	generan nuevas formas de participación en las diversas actividades.
Bravo, Ramírez, Faúndez y Astudillo (2016)	Para motivar, desarrollar el pensamiento científico y las habilidades asociadas es necesario implementar un gran número de actividades experimentales (p. 106).
De Freitas Dias y Alves (2010)	Contextualización de la enseñanza de la ciencia, considerando los intereses y necesidades de aquellos que aprenden (p. 278).
Padilla *et al.* (2016).	Clases más prácticas y vivenciales.
Macedo (2016)	Una formación de educadores de ciencias que permita cambiar las maneras de enseñar, a partir de la indagación, de situaciones de problemas abiertos y contextualizados (p. 14).
Ortega y Gil (2018)	Enseñar con un enfoque que enfatice la ciencia y la tecnología.
SEP (2017)	Establecer una relación más explícita con el medio natural y con la sociedad.
Arteaga *et al.* (2016)	Desarrollar formas de actividad y de comunicación colectivas que favorezcan la interacción de lo individual con lo colectivo.
Serna (2015)	Para hacer ciencia hoy es necesario tener mente abierta, interactuar con múltiples disciplinas e inmiscuirse en problemas complejos (p. 50).

Fuente. Elaboración propia

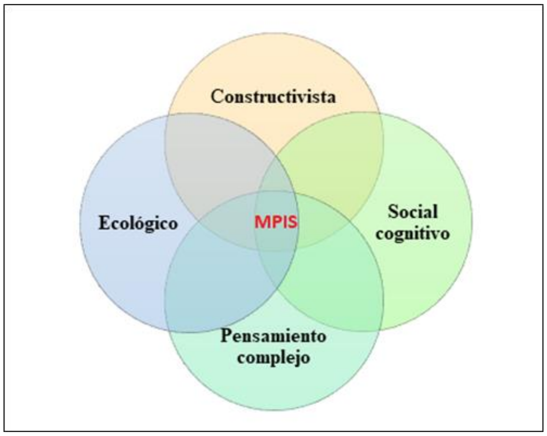
Based on the above considerations, then, pedagogical models that jointly improve the teaching process were studied, for this purpose traditional models were excluded and research focused on those who consider the student as the protagonist of the educational process, a contextualized education with an emphasis on learning, that is, having the same starting point, the reason for this is that if two models try to explain the same phenomenon of reality they are not inconsistent (Galagovsky and Adúriz, 2001), no However, each one has certain characteristics that make it unique and interesting. Next, they are mentioned and it is explained why these models were chosen.

- Constructivism: Considers the student's previous knowledge, experiences and interests in order to apply them to their personal, local and global environment (Sanmartí and Márquez, 2017). In this way, it makes the student the protagonist of the educational process, always through the development of analytical, critical, creative thinking that promotes the construction of knowledge and is oriented towards science (Pantoja and Covarrubias, 2013).

- Cognitive social: The social source is considered of special relevance in defining the purposes of the teaching of science. This is because it is essential to propose a curriculum related to social needs to avoid ruptures between the world and the school (SEP, 2017). Likewise, the teaching of science has the duty to prepare the human being for life and this is achieved not only through knowledge, but allowing the search for knowledge from problematic environments taken from the environment, where you can assess the possibilities of application of science in life (Arteaga et al., 2016).
- Complex thinking: Nowadays science is dynamic, complex and transdisciplinary, since the problems are integral, which implies that solutions that respond to these needs are required (Serna, 2015). For this reason, it is necessary to approach from the complexity that not only focuses on the enormous amount of interactions between the elements but also includes uncertainty (García and Buitrago, 2017).
- Ecological contextual: This paradigm facilitates and supports the assimilation and conceptualization of the surrounding environmental aspects, and thus provokes an awareness of respect for the surrounding context and the environment (Trujillo, 2017). According to Torres (2010), he argues that science should allow the inhabitants of the planet to achieve a healthy and balanced environment, with the aim of building a sustainable and fair world; For this, values must be developed and that give guidelines on how to intervene in individual contexts, society and the environment in a responsible and informed manner. (Adúriz *et al.*, 2011, p.15).

Figure 6 shows the MPIS that arises from the need to propose a comprehensive solution from different approaches that involves the greatest number of factors that affect the teaching of science and thus give rise to a hybrid model. Following Menéndez and Fernández (2016, p. 115) this time, this can be an interesting option in the educational field by allowing the teaching-learning process to benefit from the advantages that each model provides.

Figura 6. Modelos pedagógicos que integran el MPIS



Fuente: Elaboración propia

However, taking into account the previous bases, it is possible to briefly explain the advantages and disadvantages of each model outlined above:

- Constructivism: This model has a great presence today, since in the educational process the previous conceptions of the students are considered, their environment, interaction with classmates, provide room for error as a method for building universally valid knowledge (Vergara and Accounts, 2015, p. 930), with all of which a proactive attitude is promoted.

In the same sense, it visualizes the student as responsible for the construction of their own learning, in which they integrate environments to conceptual, procedural and attitudinal global axes, where learning is a construction to modify the mental structure and achieve high levels of complexity , integration and diversity (Flórez, 1999), which produces flexible learning.

  - Advantages: It develops learning from the most complex to the simplest, favors the coordination of motor experiences, which allows it to develop superior cognition (Vargas and Jiménez, 2014); thus, it generates a greater intellectual development in the students, without leaving aside that it is a model that considers the social aspect in education (Méndez, Villalobos, D'Alton, Cartín y Piedra, 2012, p.48).
  - Disadvantages: It stimulates individualism, since it is aimed at the object of study, which is used as a platform for the construction of their knowledge and epistemological problems, since it does not explain what the teacher's role is and how it influences the student, since constructivism stems from the fact that the student builds knowledge alone (Vargas y Jiménez, 2014).

It should be added that it is a pedagogical model that lacks a consistent and unified scientific approach to cognitive development, in addition to giving high priority to language as the main tool, which implies that a high level of linguistic knowledge by the teacher is required . Also, constructivism is emerging as an expensive option due to resources, time and difficult implementation. (Méndez *et al*., 2012, p. 48).

- Cognitive social: This model is currently present in the teaching-learning processes because it allows both the process and the evaluation to be dynamic, which makes learning meaningful in students (Vergara and Accounts, 2015, p .933). In addition, learning depends on the social and cultural context of the students, which is constructed from social interactions, which is linked to the next development zone proposed by Vygotsky.

The cognitive social model develops skills and interests in students based on the social and cultural context, focusing on reality, theory and praxis, promotes productive work, contextualized in problems, promotes the role between teacher and student horizontally and bidirectional (Flórez, 1999).

- Advantages: Develops skills and interests of students in relation to their social and cultural context that promotes scientific knowledge (Flórez, 1999), promotes intrinsic motivation, objectives are set for abilities (cognitive processes), values (affective processes) (Trujillo, 2017, p. 58). In addition to the above, the issues or problems are raised in a concrete reality and are worked in an integral way with the same community (Vives, 2016).
- Disadvantages: The student learns to perform a task without it being the appropriate way to do it. It is possible that there is no initial motivation and is visualized in only one direction and from a single approach. It is also a model that implies too much time.
- Complex thinking: The main characteristics of this model is that it includes the human being in an integral way. Believes that thought is not reductionist or totalizing but reflective. For this, knowledge must be contextualized, globalized, dynamic and emerging, which is constructed and not given by transfer. The teacher's role is to consider the human being in an integral way (Morin, 1999).

It is worth mentioning that this paradigm is oriented to the reconstruction of the subject, of knowledge, of the world and of life, since the systems of ideas, theories and knowledge are dynamic, so it turns out that it is only possible to allow each student to build, Search and be responsible for your own training process (García and Buitrago, 2017, p. 121).

Within this same order of ideas, this model considers that learning is an emerging phenomenon that involves various processes (neuronal, bodily, emotional and environmental), which cannot be reduced to only one of its components, so it is considered that learning is unexpected and, in most cases, impossible to predict, and that the content is both simple and complex (Serna, 2015, p. 119).

- Advantages: Promotes reflective, critical and proactive thinking in students, seeks the integral formation of students, studies the educational phenomenon from different perspectives, integral to various disciplines, neglects reductionist thinking.
- Disadvantages: Consider uncertainty, which leads to erroneous visions of reality, which in turn produces epistemological obstacles (Serna, 2015).
- Ecological context: This model is based on the fact that knowledge is built and complemented by what students contribute, therefore, it requires studying the person-group-environment interactions, since the teaching-learning process depends on factors personal, psychosocial and context. And so he is able to generate in the student an active, reflective, innovative, critical and research attitude; Hence, it incorporates the personal, family, school, local and global context of students from a holistic, global perspective, with planetary, collective and sustainable criteria (Trujillo, 2017).
- Advantages: Consider the interactive and continuous teaching-learning process, including unobservable processes such as thoughts, beliefs, perceptions and attitudes (Trujillo, 2017).
- Disadvantages: Gimeno and Pérez (2008, p. 135) mention that it is a paradigm that focuses on the analysis of what happens in the classroom neglecting the theological part of all educational activity, and perhaps it is a model that dismisses the importance of the contents and learning experiences by focusing on the interests and concerns of the students, which are far from the contents and experiences that constitute the official curriculum.

Based on the above, the changes and actions that need to be implemented are proposed in order to improve the teaching-learning process (véase tabla 5).

Tabla 5. Cambios y acciones para propiciar una mejor enseñanza y aprendizaje en ciencias experimentales

Cambios	**Acciones**
Desarrollar habilidades y capacidades que le permitan a los alumnos construir nuevos conocimientos científicos por cuenta propia, conocimientos que le ayuden a comprender su realidad para descartar información seudocientífica o creencias.	Enseñar a partir de situaciones problemáticas abiertas y contextualizadas, considerando la incertidumbre de la realidad.
El estudiante debe de tener la capacidad de integrar los contenidos de cada una de sus asignaturas, con la finalidad de aplicarlas en su entorno personal, social o profesional.	Enseñar la ciencia desde problemáticas actuales y de interés social, que se aborde a partir de diferentes visiones, considerando experimentos prácticos y teóricos para proponer soluciones integrales y propiciando un enfoque transdisciplinario.

Contribuir a la formación de individuos con valores que propicien el pensamiento crítico, reflexivo y propositivo.	Promover estrategias activas, participativas y creativas que estimulen el progreso del alumno.
Promover un conocimiento pertinente.	Situar una enseñanza en contexto, a causa de que la ciencia es un producto de la sociedad, de la cultura y del entorno.
Propiciar emociones positivas en los alumnos con respecto a las asignaturas que conforman el área de experimentales.	Atender la parte afectiva, emocional, social, cultural, psíquica y cognitiva de los estudiantes.
Formar un estudiante interesado en aspectos políticos, ambientales, económicos, entre otros, y que participe de manera activa, informada y con valores.	Considerar el desarrollo de los estudiantes a partir de los diversos ambientes en los que desenvuelve y que pueden influir en el cambio del progreso cognitivo, relacional, actitudinal y moral
Las evaluaciones son integrales, permanentes y dinámicas considerando el contexto y los propósitos académicos.	Promover la heteroevaluación, coevaluación; favorecer las autoevaluaciones con la finalidad de que los alumnos conozcan sus fortalezas y sus debilidades.

Fuente: Elaboración propia

Results

According to the corresponding analysis, the MPIS is proposed, which is made up of four holons or levels, which refers to the fact that they are part of a global system. Next, each holon or level is briefly explained (see figure 7):

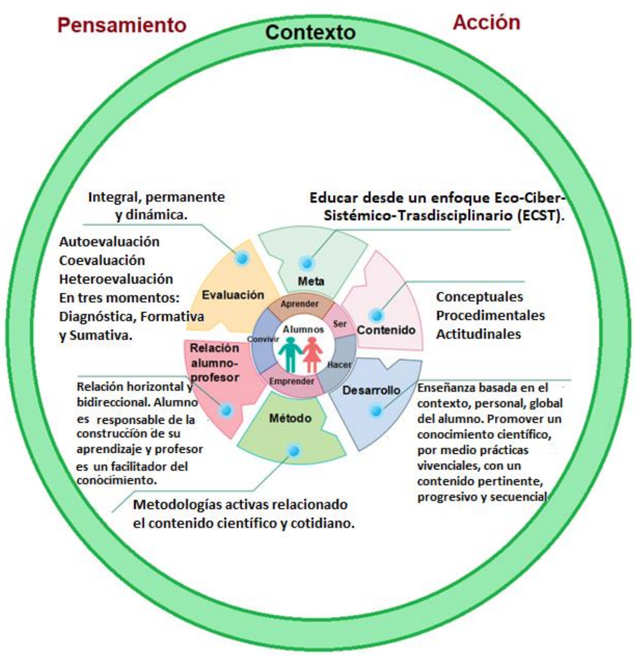
• First holon: It is the starting point of the model, considering the students as the center of the learning process, since it is necessary to identify the knowledge, skills, attitudes that students possess to integrate them into the teaching-learning process, since to To achieve significant learning it is necessary to relate the school environment and the environment so that the student perceives the usefulness of the knowledge acquired and thus propitiate an intrinsic motivation.

• Second holon: Includes the skills that are intended to be achieved with students: learn-learn, learn-be, learn-do, learn-live and learn-undertake. And that these are based on the social, cultural, ecological and technological context of the student, considering that today an education is demanded that contributes to the progress of a country, since it raises commercial, industrial and, in general terms, Improve Life Quality.

• Third holon: Refers to broad features of the characteristics of the pedagogical model (goals, content, development, method, teacher-student relationship and evaluation).

• Fourth holon: Corresponds to the contexts in which students develop according to the ecological theory of Bronfenbrenner systems, where the context is hierarchized and divided into the following levels: microsystems, which are shaped by relationships that have direct contact with the student (classmates, teacher, parents, school); mesosystem, which are the interconnections that comprise two or more environments in which students actively participate (family, friends, social life, among others); exosystem, are the interconnections that occur between the media in which the individual does not actively participate, but in which facts or decisions originate that directly disturb the student (community, education system, media, social networks), and the macrosystem, which is interconnected with the characteristics of society and its culture (society, culture, norms, among others).

Figura 7. MPIS



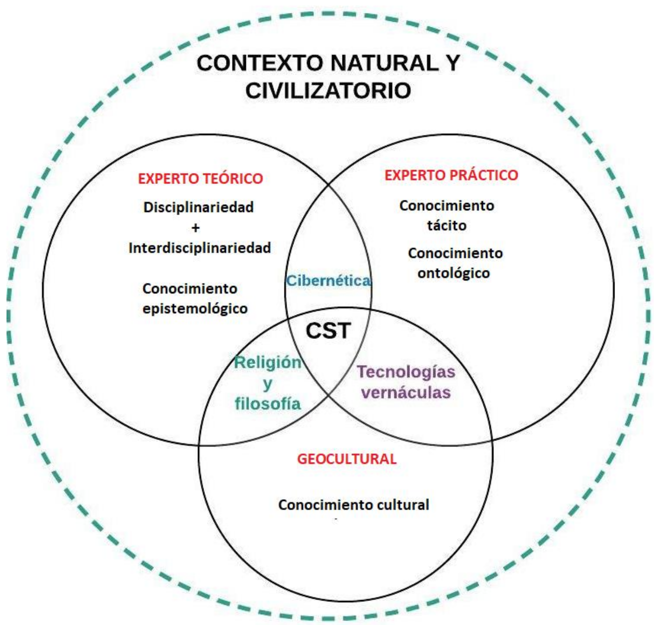
Fuente: Elaboración propia

The MPIS model is focused on active and participatory methods for integral development; part of the fact that students have knowledge of a rational, emotional, empirical and intuitive type that must be organized in a gradual, didactic and complementary way and thus achieve a greater impact on learning.

It should be added that the MPIS has an eco-cyber-systemic-transdisciplinary approach, since it integrates thought, action and culture, which gives rise to transdisciplinarity; and if it is assumed that the educational process is constituted by biological, open, dynamic and social systems, in which control and communication processes are involved, which in the educational field intends to improve the communicative and informative process among the student, peers, teaching resources and the teacher through feedback, then cybernetics are alluded to.

Likewise, the relationships of the microsystem, mesosystem, macrosystem and exosystem of the participants that link the natural and civilizational context must be considered; in other words, include ecological knowledge in the development of the teaching-learning process for the adequate construction of knowledge (see figure 8).

Figura 8. Enfoque eco-ciber-sistémico-transdisciplinario



Fuente: Elaboración propia con base en Licona, Ortega, Hernández y Peón (2017)

Discussion

The teaching of science in the new millennium demands profound transformations from elementary education to university, so that the teacher ceases to be a transmitter of finished knowledge and becomes aware that his job is to create the possibilities for the student to produce and build your knowledge (Arteaga et al., 2016).

On the previous ideas it is necessary to promote an integral education from different pedagogical approaches that lead to hybrid models, that is, the combination of two or more orientations, since “there is no single or omnipotent pedagogical model that solves all the problems of learning that students have ”(Ortiz, 2011, p.135); also, because each pedagogical model has its advantages but also its weaknesses, so they do not allow to be fully applied (Flórez, 1999, p. 55).

Based on the above considerations, the models should be modified based on scientific and technological advances, since, according to Galagovsky and Adúriz (2001), these are provisional and perfectible constructions. Also, according to Ortiz (2011), “it is essential that in any conception that is assumed, it is done from a more holistic, complex, dialectic and systemic view of thought” (p. 130), in order to potentiate the maximum students' abilities to generate learning applicable to complex situations (Abarca, 2007).

One of the strengths of this model is that it integrates the particularities of pedagogical models already tested and in which good results have been obtained. The purpose of proposing the MPIS is to involve a greater number of aspects that can improve the effects obtained so far in the ACE. The limitation of this research is that it is a theoretical proposal that is based on what students are expected to achieve. And if González's words are taken up again (2015, p. 17): if learning science is difficult, then teaching science is not an easy task either.

Conclusion

The proposal of this MPIS is not intended to replace any model, but to propose an integral alternative in which the characteristics and qualities of different pedagogical models are used that, together, can cover a greater number of factors involved in the educational process. While it is complicated for a model to address all the variables that exist in a classroom, this does not mean that the models must stagnate; On the contrary, these have to evolve according to the requirements of society.

It should be noted that the whole development of the present study focused on the difficulties, the purposes and how it should be the teaching of science, in order to choose the characteristics of each model that, when integrated, provide an identity to the MPIS; but the implementation for another phase of the investigation must be ignored: A case study in the CCH and thus be able to know its scope and limitations.

Finally, a line for future research could be oriented to study models, paradigms, techniques, methods, among other resources, which have been used in educational environments, and assess how effective they would be if combined, what their limitations and their scope would be if They work together.

References

Abarca, R. R. (2007). *Modelos pedagógicos educativos de excelencia*. Arequipa, Perú: Universidad Católica de Santa María.

Adúriz, A., Gómez, A. A., Rodríguez, D. P., López, D. M. Jiménez, M. P., Izquierdo, M. y Sanmartí, N. (2011). *Las ciencias naturales en Educación Básica: formación de ciudadanía para el siglo XXI* (1.ª ed.). Ciudad de México, México: SEP.

Arteaga, E., Armada, L., y Del Sol, J. L. (2016). La enseñanza de las ciencias en el nuevo milenio. Retos y sugerencias. *Revista Universidad y Sociedad*, *8*(1), 169-176.

Bournissen, J. M. (2014). Modelo pedagógico virtual. *Signos Universitarios*, anejo 2, *1*, 245-266.

Bravo, A. A, Ramírez, G. P., Faúndez, C. A. y Astudillo, F. (2016). Propuesta didáctica constructivista para la adquisición de aprendizajes significativos de conceptos en física de fluidos. *Formación universitaria*, *9*(2), 105-114.

Checkland, P. and Scholes J. (1990). *Soft systems methodology in action*. Chichester, England: Wiley.

Checkland, P. (2013). Soft Systems Methodology. In Gass, S. I. and Fu, M. C. (eds.), *Encyclopedia of Operations Research and Management Science* (1430-1436). Boston, Estados Unidos: Springer.

Dávila, M. A., Borrachero A. B., Cañada, F., Martínez, G. y Sánchez, J. (2015). Evolución de las emociones que experimentan los estudiantes del grado de maestro en educación primaria, en didáctica de la materia y la energía. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, *12*(3), 550-564.

De Freitas Dias, K. A. y Alves, A. (2010). Reflexiones sobre el papel de la contextualización en la enseñanza de ciencias. *Enseñanza de las ciencias, 28*(2), 275-284.

Drăghicescua, L. M., Petrescua, A. M., Cristeab, A. G., Gorghiuc, L. M. and Gorghiu, G. (2014). Application of Problem-Based Learning Strategy in Science lessons- Examples of Good Practice. *Procedia – Social and Behavioral Sciences, 149*(2014), 297-301.

Furman, M., Luzuriaga, M., Taylor, I., Anauati, M. V. y Podestá, M. E. (2018). Abriendo la "caja negra" del aula de ciencias: un estudio sobre la relación entre las prácticas de enseñanza sobre el cuerpo humano y las capacidades de pensamiento que se promueven en los alumnos de séptimo grado. *Enseñanza de las ciencias, 36*(2), 81-103.

Flores, F. (2012). *La enseñanza de la ciencia en la educación básica en México*. Ciudad de México, México: INEE.

Flórez, R. (1999). *Evaluación pedagógica y cognición*. Bogotá, Colombia: McGraw-Hill.

Galagovsky, L. y Adúriz, A. (2001). Modelos y analogías en la enseñanza de la ciencia de las ciencias naturales el concepto de modelo didáctico analógico. *Enseñanza de las ciencias, 19*(2), 231-242.

García, M. S. y Buitrago, Y. C. (2017). Modelo pedagógico de pensamiento complejo en diseño gráfico. *Revista Logos Ciencia y Tecnología*, *8*(2), 119-131.

Garzón, M. A. y Pérez, R. (2015). Lenguaje y los modelos en la enseñanza de la química. El caso de fenómeno químico. *ACTAS, 3*. Recuperado de http://filosofiaeducacion.org/actas/index.php/act/article/view/153.

Gimeno, J. y Pérez A. (eds.) (2008). *La enseñanza: su teoría y su práctica*. Madrid, España: Akal.

González, F. (coord). (2015). *Didáctica de las ciencias para la educación primaria*. Madrid, España: Pirámides.

Instituto Nacional para la Evaluación de la Educación [INEE]. (2016). *México en PISA 2015* (1.ª ed.). México: INEE

Licona, J., Ortega, A., Hernández, L. y Peón, I. (2017). Diagnóstico sistémico transdisciplinar de las instituciones de educación superior promotoras de los derechos humanos de las mujeres. *Revista de Teoría Educativa*, *1*(1), 31-43.

López, Z. (2015). La enseñanza de las ciencias naturales desde el enfoque de la apropiación social de la ciencia, la tecnología y la innovación ASCTI, en educación básica-media. *Revista científica*, *2*(22), 75-84.

Macedo, B. (2016). *Educación científica*. Montevideo, Uruguay: Unesco.

Martínez, N. Y. y Riveros, S. Y. (2019). La enseñanza de caída libre bajo la metodología de aprendizaje activo. *Tecné Episteme y Didaxis: TED,* (45), 35-56.

Matthews, M. R. (2017). *La enseñanza de la ciencia. Un enfoque desde la historia y la filosofía de la ciencia* (1.ª ed.). Ciudad de México, México: FCE.

Menéndez, J. I. y Fernández, J. (2016). Hibridación de los modelos de Educación Deportiva y Responsabilidad Personal y Social: una experiencia a través de un programa de kickboxing educativo. *Retos. Nuevas Tendencias en Educación Física, Deporte y Recreación*, (30), 113-121.

Méndez, V., Villalobos, A., D´Alton, C., Cartín, J. y Piedra, L. A. (2012). *Los modelos pedagógicos centrados en el estudiante: apuntes sobre los procesos de aprendizaje y enseñanza*. San José, Costa Rica: Programa de Investigación en Fundamentos de Educación a Distancia

Morin, E. (1999). *Los siete saberes para la educación del futuro*. París, Francia: Unesco.

Organización para la Cooperación y el Desarrollo Económicos [OCDE]. (2015). *Programa para la Evaluación Internacional de Alumnos (PISA) PISA-2015 — Resultados*. Nota País/OCDE. Recuperado de https://www.oecd.org/pisa/PISA-2015-Mexico-ESP.pdf.

Ortega, V. y Gil, C. (2018). Estudio de aplicación de modelos didácticos de ciencias experimentales en un proyecto comunidad de aprendizaje. *ReiDoCrea, 8*, 80-94

Ortiz, A. (2011). Hacia una nueva clasificación de los modelos pedagógicos: el pensamiento configuracional como paradigma científico y educativo del siglo XXI. *Praxis*, *7*(1), 121-137.

Padilla, C., Brooks, P., Jiménez, L. D. y Torres, M. I. (2016). Dimensiones de las competencias científicas esbozadas en los programas de estudio de Biología, Física y Química de la Educación Diversificada y su relación con las necesidades de desarrollo científico-tecnológico de Costa Rica. *Revista Electrónica Educare, 20*(1), 1-26.

Pantoja, J. C. y Covarrubias, P. (2013). La enseñanza de la biología en el bachillerato a partir del aprendizaje basado en problemas (ABP). *Perfiles educativos*, 35(139), 93-109.

Reimers, F. y Chung, C. K. (2016). *Enseñanza y aprendizaje en el siglo XXI: metas, políticas educativas y currículo en seis países*. Ciudad de México, México: FCE.

Sanmartí, N. y Márquez, C. (2017). Aprendizaje de las ciencias basado en proyectos: del contexto a la acción. Ápice. *Revista de Educación Científica*, *1*(1), 3-16. Recuperado de https://doi.org/10.17979/arec.2017.1.1.2020.

Secretaría de Educación Pública [SEP]. (2017). Campo Disciplinar de Ciencias Experimentales Bachillerato General-Adecuación de contenidos de las asignaturas del componente de formación propedéutica básica. México: Secretaría de Educación Pública. Recuperado de https://bit.ly/30ZYxNZ.

Serna, E. (2015). *Ciencia y pensamiento complejo – Desarrollo transdisciplinar de un paradigma* (1.ª ed.). Medellín, Colombia: Instituto Antioqueño de Investigación.

Torres, M. I. (2010). La enseñanza tradicional de las ciencias versus las nuevas tendencias educativas. *Revista electrónica Educare*, *14*(1), 131-142.

Trujillo, L. M. (2017). *Teorías pedagógicas contemporáneas*. Bogotá, Colombia: Fundación Universitaria del Área Andina.

Vargas, C. y Jiménez, S.I. (2014). Constructivismo en los procesos de educación en línea. *Revista Ensayos Pedagógicos, 8*(2), 157-167.

Vergara, G. y Cuentas H. (2015). Actual vigencia de los modelos pedagógicos en el contexto educativo. *Opción, 31*(6), 914-934.

Vives, M.P. (2016). Modelos pedagógicos y reflexiones para las pedagogías del Sur. *Boletín Redipe*, *5*(11), 40-55.

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