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CRITICAL THINKING IN HIGHER EDUCATION TECNM - TLÁHUAC, STUDIES PRECEPTOR

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Abstract: Critical Thinking Model for Technology Education (MPCET) has as its fundamental principle the construction and permanent reconstruction of knowledge, not only scientific and technological thinking, but also everyday thinking, considering that human thinking as well as all objects, phenomena and processes of nature and society are in constant change, transformation and movement. Critical thinking is that way of thinking - about any subject, content or problem - in which the thinker improves the quality of his thinking by taking hold of the inherent structures of the act of thinking and subjecting them to intellectual standards. Critical thinking is self-directed, self-disciplined, self-regulating, and self--correcting. It involves submitting to rigorous standards of excellence and conscious mastery of its use. It involves effective communication and problem-solving skills and a commitment to overcoming natural human self-centeredness and socio-centeredness. One of the central purposes of education is oriented to the formation of critical thinking in students and teachers in the classroom, for that purpose, it is necessary to understand and analyze the different constructions that are woven when actions that lead to form critical thinkers that enhance changes in today's society are oriented. For these reasons, a theoretical reflection is presented that seeks to analyze the different perspectives on critical thinking and its main constituent categories.
Keywords: critical thinking, didactics, argumentation, metacognition, problem solving.

INTRODUCTION

The central purpose that currently guides actions in the fields of education and pedagogy is the formation of critical thinking. This topic, with a long history in philosophy, psychology, pedagogy and, in general, the social sciences, is gaining relevance today. Specifically from the work in the classroom, the formation of critical thinking, particularly in the field of specific domains of knowledge, is the central purpose of science didactics. *The problem: Everyone thinks; it is part of our nature. But, much of our thinking, by itself, is arbitrary, distorted, biased, uninformed or prejudiced. However, our quality of life and of what we produce, do or build depends precisely on the quality of our thinking. Poor quality thinking costs both in money and in quality of life. Excellence in thinking, however, must be exercised systematically.* The teaching process and the learning of principles, concepts and theories in the different disciplinary fields take second place, since what is fundamental is the formation of subjects and communities that think and act critically with the learning acquired at school. To this end, research results are presented based on the categories: argumentation, problem solving and metacognition, which must be present, intentionally and consciously, both in the teaching processes of teachers and in the learning processes of students (Paul & Elder, 2021). It is clear, then, that in general terms the central purpose of the school, in all its levels and modalities, is to contribute to the integral formation of citizens, a formation that implies taking into account the different dimensions of human and social development. From this broad perspective of education, a central purpose is: the formation of thought and, in particular, the formation of critical thinking in specific domains of knowledge.

We have as a result a critical and exercised thinker: Formulates vital problems and questions, with clarity and precision, Accumulates and evaluates relevant information and uses abstract ideas to interpret that information effectively, Reaches conclusions and solutions, testing them against relevant criteria and standards, Thinks with an open mind within alternate systems of thought; recognizes and evaluates, as necessary, assumptions, implications and practical consequences, and In devising solutions to complex problems, communicates effectively. (Nossidch, 2020).

The following pages show some of the current tensions between the fields of knowledge of pedagogy and didactics, describe in some detail the purposes of didactics in terms of teaching, learning and, especially, in relation to the central object of science didactics: the formation of critical thinking in specific domains of knowledge.

MATERIALS AND METHODS

A) CRITICAL THINKING PROCESS.

Art - Science

Teaching has marked a path for several decades, in which didactics is considered as a sphere of pedagogy in charge of teaching actions, that is, in a I know, I confront, I build and I contribute (New Educational Model TecNM 2024). However, more recent developments in this field consider learning as one of the dimensions in which teachers-instructors must show their strengths, so that the teaching actions they deploy in their classrooms are mediated by the detailed knowledge of the processes through which students learn what teachers teach. From another perspective, the didactics of science is conceived as the ternary relationship between a knowledge that is taught, a group of teachers who teach this knowledge, and another group of students who learn it, within the framework of a given social context. Here the purpose of didactics is oriented towards the acquisition of certain knowledge. A third perspective, which for the authors of this article is the most determinant at the present time of science didactics, orients its object of study towards the formation of critical thinking in specific domains of knowledge. From this theoretical point of view, the didactics of science would have as its point of arrival the constitution of critical thinking in students in each of the fields of knowledge, for which it would undoubtedly make use of the teaching of the different concepts that have traditionally been taught and, likewise, of some of the strategies already tested historically as well as those others aimed at achieving better understanding of what students have learned.

The constitution of critical thinking requires new ways of understanding the relationships between students, teachers and the knowledge that circulates in the classroom. Among the reasons for proposing this mobilization are: the difficulty that students have in using the knowledge that have in the explanation and understanding of everyday phenomena, the inefficiency of traditional didactic actions in terms of making students learn the fundamental concepts of science and not a caricature of them, as well as their inability to understand the operation of the machines they use every day and to apply the principles of their operation (Tamayo, 2009). The development of critical thinking requires then, on the one hand, the exploration and recognition in the subject at an early age of their representational models and cognitive skills through didactic proposals based on the school-science-subject-context relationship. On the other hand, it is necessary to establish the relationship between the development of critical thinking in children and the internal dynamics that characterizes it, that is, to articulate this development to conscious cognitive processes, to promote self-regulatory spaces that allow making the process more efficient and to provide support tools for planning, monitoring and evaluation of the processes leading to its development (Al-Ahmadi, 2018; Tamayo, Zona & Loaiza, 2014).

With the ideas presented so far, many of the multiple perspectives that have been taken into account so far to conceptualize critical thinking are enunciated in this section we present some theoretical developments around three central categories in the constitution of critical thinking in students, these are:

General Formation

The study of language and argumentation in science is currently one of the highest priority lines of research in science didactics (Lemke, 2020; Sutton, 2018; Candela, 2018). Regarding argumentation in science classes, Duschl and Osborne (2022) emphasize the importance of developing research that allows students to approach from their classrooms to the forms of scientific work typical of academic communities, within which those referring to the multiple uses of language and argumentation stand out in a special way.

On the other hand, Jiménez & Díaz de Bustamante (2023), Sardà, Márquez & Sanmartí (2015) and Campaner & De Longhi (2017) highlight the field of science education as a space in which students' argumentative skills can be enhanced, given that one of the purposes of scientific research is the generation and justification of statements and actions aimed at understanding nature (Jiménez, Bugallo & Duschl, 2020, cited by Jiménez & Díaz de Bustamante, 2022).

In the classroom this process would be evidenced through the students' discursive practices in which components of the structure of argumentation, scientific concepts and discursive practice are articulated, whose staging would allow to know the characteristics of argumentative models and, from there, to build didactic processes that contribute to the transformation of such models.

Some concepts about the term 'argumentation' relevant to the research, then the perspectives, types and forms of arguments students resort to in order to express their points of view and, finally, how students argue in science classes are pointed out.

For Sardá (2003, p. 123), argumentation "is a social, intellectual and verbal activity that serves to justify or refute an opinion, and which consists of making statements taking into account the receiver and the purpose for which they are issued. To argue it is necessary to choose between different options or explanations and reason the criteria that allow to evaluate as more adequate the chosen option".

For other authors, argumentation is oriented towards convincing or persuading. Perelman and Olbrechts-Tyteca (1997, p 72) consider that the purpose of argumentation "is to convince with reasons or to persuade through affective resources". On the other hand, as expressed by Driver and Newton (2000, p 84):

Dialogic or multiple voice argumentation takes place when different perspectives are examined by an individual or within a group in order to reach an agreement on which knowledge statements are accepted or which courses of action are taken into consideration.

(Candela, 2018), takes up the consensus orientation in his research when he points out that:

> (...) argumentation and the search for agreement and, ultimately, consensus, are two aspects that can be complementary and are based on the same intention. Argumentation is often used to convince of the validity of a version of knowledge and therefore to reach consensus.

Troubleshooting

Metacognition has been defined as the ability to monitor, evaluate and plan our own learning (Flavell, 2020). In an even more general way it was defined by (Flavell 2022), as any knowledge about knowledge. From these first definitions, in the last two decades important efforts have been made with the purpose of having a more detailed knowledge of metacognition and its relationship with learning processes. Consequently, there is currently a broad theoretical construct (Martí, 2021; Gunstone & Mitchell, 2022; Mayer, 2021; Sternberg, 2020; Tamayo, 2022) and an important variety of methodological strategies for its assessment (Pintrich, Marx & Boyle, 2020;

Tobias & Everson, 2021; Osborne, 2020) that allow us to refer to metacognition as a young concept with great potential in science education (Ustárroz, 2021).

This author mentions (Gunstone and Mitchell 1998), the study of metacognition addresses three general aspects: knowledge, awareness and control over one's own thought processes. Metacognitive knowledge is knowledge that can refer, according to (Flavell, 2020), to knowledge about people, about tasks or about strategies. A student who is adequately aware of his cognitive processes can "talk" or "reflect" on his own and/or others' thought processes; in this sense, this type of knowledge is central to the formation of critical thinking.

Conditional knowledge is a knowledge of why and when declarative and procedural knowledge is used (Garner, 1990; Mayer, 1998). According to Reynolds (1992, cited by Schraw, 1998), this type of knowledge helps the learner to selectively allocate resources and use strategies more efficiently; it also allows identifying the set of conditions and situational demands of each learning task. This knowledge is considered as a type of strategic knowledge of importance for many researchers due to its influence on education. It consists of being able to deploy a series of strategies and knowing how to analyze the situation in order to know which are the most appropriate.

The regulation of cognitive processes is mediated by three essential cognitive processes: planning, monitoring, and evaluation (Brown, 2019). Planning involves selecting appropriate strategies and locating factors that affect performance such as prediction, sequencing strategies, and time allocation or selective attention before performing the task. That is, it consists of anticipating activities, forecasting outcomes, enumerating steps. Monitoring refers to the possibility one has, at the moment of performing the task, to understand and modify its execution, for example, to perform self-evaluations during learning, to verify, rectify and review the strategies followed. The evaluation, performed at the end of the task, refers to the nature of the actions and decisions taken by the learner, and evaluates the results of the strategies followed in terms of effectiveness.

Knowledge and cognition regulation are mutually related. Martí (1995) considers that it is very likely that the knowledge a person has about his or her cognition has an impact on cognitive regulation; similarly, he considers that it is likely that the regulatory processes applied by people when approaching a learning task have an impact on the knowledge they are developing and on their own cognitive processes.

RESULTS AND DISCUSSION

It is clear that this text presents some of the central tensions between the fields of knowledge of pedagogy and didactics. Likewise, the object of study of science didactics is specified in terms of the development of domain-specific critical thinking, an aspect that led to the presentation of reflections on three central dimensions: Art-Science, General Training, and problem solving, which constitute the central axes in the formation of critical thinking. These categories will be presented in subsequent research works, with the purpose of orienting critical thinking according to the characteristics of our educational context.

In summary, it is important to clarify that, in order to form critical thinking in students, it is necessary to focus the discussion around the following central aspects:

- Recognize the cognitive structure of the subject, its history, experience, thinking: Peter (Facione 2017) argues that critical thinking appeared long before schooling was invented, it lies in the very roots of civilization.

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- Fostering relationships between science and its public understanding (Fensham & Harlem, 1999), on public understanding of science (Cross, 2019) and on the relationships between science, technology, society and development.
- Assessment of the dynamics of science itself, its internal and external functioning that make it functional according to the context and teaching-learning conditions. It is necessary to recognize that the teacher must possess knowledge about the Nature of Science (Tamayo & Orrego, 2005), not to "pretend to reproduce in the school this type of metacognitive reflection, nor to go deeply into the complex epistemological problems that are still pending resolution. The goal should not focus so much on the philosophy or sociology of science, as if to train students to become specialists in these fields of knowledge (Smith & Scharman, 1999), but rather to help them better understand how contemporary science and technology work" (Acevedo et al, 2015).
- Implementation of conscious processes in science learning, as a mechanism to deepen and understand how the subject learns, in order to articulate much more meaningful teaching processes.

School as a scenario that offers the possibility not only of accessing knowledge, but also as the space where children enrich their intellect and where they gather fundamental contributions to construct or reconstruct knowledge in a conscious manner.

Similarly, it is important to understand that some of the characteristics of critical thinkers are, among others: a) They try to identify the assumptions that underlie ideas, beliefs, values and actions. b) They possess the ability to imagine and explore alternatives to existing ways of thinking and living. c) They are usually skeptical to claims of universal truths or ultimate and definitive explanations. d) They are aware of the context.

Continuing with this discussion and retaking Bachelard's approaches (2024), it is found that in the formation of the critical (scientific) spirit different aspects intervene, among which we can mention: common sense, intuition, the use of images, analogies, metaphors, the use of generalizations, etc., these aspects are raised by the author as obstacles that must be overcome in the formation of the scientific spirit. Although the use of these strategies can favor the acquisition of new learning, taking the utmost care with their methodological use, it is not enough to place them as generators of the scientific attitude (scientific spirit for Bachelard) unless they are accompanied by other equally important actions that together will be decisive in the achievement of critical thinking, the inalienable goal of education.

Among these possible actions, the one called by Mockus (1989) rational discussion stands out, which should be the basis for the construction of the students' critical attitude. It is not enough, then, to think that the use of analogies, metaphors and images, the recovery of common sense, of the marvelous, per se, are dynamizers of critical thinking. It is necessary, in each of these cases, and necessarily recognizing the pedagogical mediation, to approach the activity carried out under the assumptions of rational discussion that brings together approaches from both universal pragmatics and sociolinguistics.

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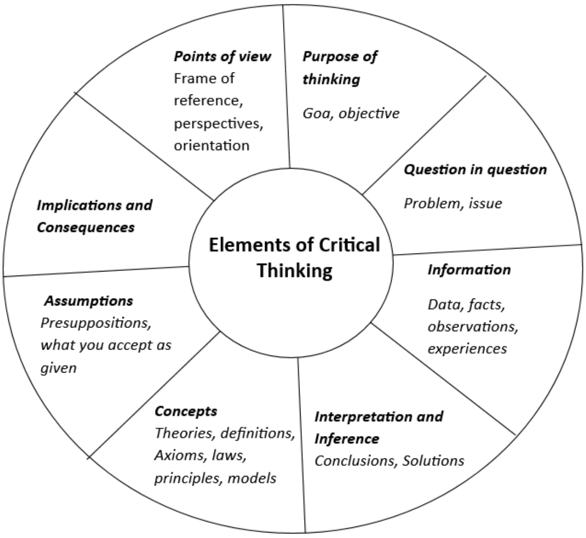

Figure 1. Elements of Critical Thinking.

Privileging rational discussion, the written tradition and the reorganization of action (Mockus, 1989) in the educational sphere has become a powerful tool that allows the development of critical thinking, the dynamizer par excellence of knowledge and the formation of subjects.

If it is understood that teaching plays a central role in the formation of critical thinking, it is then necessary to reflect on the forms and strategies used in this process. In this sense, regardless of the specific field in which one acts, the different teaching models may or may not facilitate the formation of the student's critical capacity. For Bachelard (2024) elementary teaching, the experiences too vivid or with an excess of images are the center of false interest. This is due to the fact that they impact the student so much that they can divert his real interest, without underestimating such an important aspect as motivation and the use of images in learning.

Purpose	What is my central goal? What is my purpose?
Information	What information am I using to reach that conclusion? What experiences have I had to support this statement? What information do I need to answer this question?
Inferences/ Conclusions	How did I come to this conclusion? Is there another way to interpret this information?
Concepts	What is the central idea? May I explain this idea?
Assumptions	What am I taking for granted? What assumptions lead me to this conclusion?
Implications/ Consequences	If someone were to accept my position, what would be the implications? What am I implying?
Viewpoints	From what point of view am I approaching this issue? Is there another point of view I should consider?
Questions	What question am I asking? What question am I answering?

Table 1. Questions that use the elements of thinking

(on a paper, an activity, an assigned reading . . .)

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