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The Use of Socio-Scientific Problems to Develop Critical Thinking in the Teaching of Natural Sciences

El uso de problemas socio-científicos para desarrollar el pensamiento crítico en la enseñanza de las ciencias naturales

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Abstract: This study analyzes the use of socio-scientific problems as a strategy for developing critical thinking in the teaching of natural sciences. The objective of the research was to identify teachers' perceptions and practices regarding the integration of this approach in the classroom. The research was conducted using a mixed-methods approach, combining a literature review on the topic with a survey of 22 teachers at the Edwards Deming Corporate University Technological Institute (ISTUCED). The results show that most teachers use socio-scientific problems in their classes, primarily when covering course content and through strategies such as case studies and classroom debates. Furthermore, teachers believe that using these problems fosters the development of critical thinking, connects scientific knowledge to real-world situations, and promotes informed decision-making. Among the skills developed, scientific reasoning, information analysis, and evidence-based decision-making stand out. However, difficulties related to a lack of teacher training and limited time within the curriculum were also identified. In conclusion, socio-scientific problems constitute a relevant teaching strategy for promoting a more contextualized and reflective approach to science education.

Keywords: socio-scientific issues, critical thinking, science education, teaching strategies, science education.

Resumen: El presente estudio analiza el uso de los problemas socio-científicos como estrategia para el desarrollo del pensamiento crítico en la enseñanza de las ciencias naturales. El objetivo de la investigación fue identificar la percepción y las prácticas docentes respecto a la integración de este enfoque en el aula. La investigación se desarrolló bajo un enfoque metodológico mixto, que combinó la revisión bibliográfica sobre el tema con la aplicación de una encuesta a 22 docentes del Instituto Superior Tecnológico Universitario Corporativo Edwards Deming (ISTUCED). Los resultados evidencian que la mayoría de los docentes utiliza problemas socio-científicos en sus clases, principalmente durante el desarrollo de los contenidos y a través de estrategias como el análisis de casos y los debates en el aula. Asimismo, los docentes consideran que su uso favorece el desarrollo del pensamiento crítico, además de relacionar

el conocimiento científico con situaciones reales y promover la toma de decisiones informadas. Entre las habilidades que se desarrollan se destacan la argumentación científica, el análisis de información y la toma de decisiones fundamentadas. No obstante, también se identifican dificultades relacionadas con la falta de formación docente y el tiempo limitado dentro del currículo. En conclusión, los problemas socio-científicos constituyen una estrategia didáctica relevante para promover una enseñanza de las ciencias más contextualizada y reflexiva.

Palabras clave: problemas socio-científicos, pensamiento crítico, enseñanza de las ciencias, estrategias didácticas, educación científica.

Introduction

Rote and decontextualized learning is a common problem in science education; many authors point out that scientific concepts are often taught as empty labels, without connecting them to real-world phenomena or the actions that underpin them. Today, education faces the challenge of preparing students to understand and analyze the problems affecting contemporary society. We are educating a generation of students who constantly ask themselves: Why do I need this information? Where do I apply it in my daily life? What impact will it have on my development? Therefore, teachers cannot limit themselves to being passive conveyors of knowledge that students can obviously acquire online, just a click away; their main challenge is to link academic content to the surrounding reality and to scientific advances, and to promote the development of skills that enable students to interpret scientific information, make informed decisions, and participate responsibly in social debates related to science,

According to : “A society transformed by science and technology requires that citizens possess scientific and technical knowledge and be able to respond to needs of various kinds—whether professional, utilitarian, democratic, operational, or even metaphysical and recreational.”

Based on this assertion, it is essential that classroom instruction be linked—without exception—to the real-world context of the community. It is imperative to foster critical thinking and engage students in what truly matters: humanity, its present, and its future.

In this context, the development of critical thinking has become one of the fundamental goals of education. This skill enables students to analyze information, evaluate evidence, question arguments, and draw well-founded conclusions.

One of the teaching strategies that has gained momentum in science

education is the use of socio-scientific problems, which refer to real-world situations that involve scientific knowledge and, at the same time, have social, ethical, political, or environmental implications. Examples of these problems include climate change, deforestation, biodiversity loss, genetically modified organisms, and environmental pollution, among others. Incorporating these types of problems into the classroom allows for the contextualization of scientific learning and fosters critical reflection among students, promoting argumentation, evidence analysis, and informed decision-making.

In this regard, the objective of this article is to analyze the use of socio-scientific problems as a pedagogical strategy for developing critical thinking in the teaching of the natural sciences.

To explore this topic in greater depth, we will trace the history of science education back to its origins, which stem from the human need to understand the surrounding environment. Over time, the empirical knowledge of ancient civilizations evolved into theoretical systems, particularly during Ancient Greece. Later, between the 16th and 18th centuries, modern science and its formal teaching began to take shape, shifting from traditional methods to experimental approaches and, in more recent times, to inquiry-based models in which students take on a leading role.

Take, for example, the teaching of biology as a science, which dates back to the early 19th century and was centered on direct observation, the classification of plants and animals, and knowledge of natural medicines, with a strong influence from Aristotle. In 1802, Jean-Baptiste Lamarck and Gottfried R. Treviranus popularized the term “biology.” Its teaching drew upon cell theory (Schleiden and Schwann) and Darwin’s theory of evolution by natural selection (1859), shifting its focus. Key authors highlight the transition from separate botany and zoology to a unified biology, integrating evolutionary, cellular, and genetic theories to foster critical thinking and an understanding of life in context. For example, (Canales, 2023) states that: “In the early 19th century, scientific disciplines such as the laboratory sciences (chemistry, physics, followed by botany and zoology) taught in countries like Great Britain were of great interest. Biology was not a well-known discipline, and throughout that century, the teaching of these sciences was limited.” By the 20th century, the teaching of these sciences had been integrated with genetics and molecular biology. In its early stages, this teaching was traditional, characterized by a lecture-based, rote-memorization approach centered on

the teacher as the transmitter of knowledge, prioritizing the technical reproduction of concepts, taxonomic classification, and anatomical description, while limiting critical analysis and the student's active construction of learning. This type of methodology assigns the teacher a role rooted in scholasticism: the teacher organizes and structures knowledge, serving as the authority who dictates the path of learning. Lecture-style classes, technical demonstrations, and purely procedural laboratory work predominate.

Similarly, in the history of physics education, we find the same pattern: it has undergone a significant evolution from its roots in the natural philosophy of ancient Greece—represented by thinkers such as Aristotle—and the contributions to mechanics made by Archimedes, to contemporary approaches grounded in experimentation. Over time, it shifted from geocentric conceptions of the universe to heliocentric models championed by scientists such as Copernicus and Galileo, subsequently consolidating with the development of classical mechanics and, later, with the advances in modern physics led by Einstein. In light of the imminent changes in the current landscape, (Zubiría, 2014) argues: “However, the traditional school has become obsolete in recent decades in the face of significant social, economic, and political changes experienced worldwide. Society has become global and interconnected; the world has become more flexible and diversified, and has increasingly taken the individual into account.” (p. 2)

The limitations of traditional teaching models show that the transmission of content alone does not guarantee a deep understanding of phenomena or the ability to apply scientific knowledge in everyday life. For this reason, contemporary science education has begun to prioritize the development of cognitive skills that enable students to interpret information, evaluate evidence, and participate in an informed manner in scientific and social debates. Among these competencies, critical thinking plays a central role, as it is an essential tool for understanding science, questioning claims, and making informed decisions. Consequently, it is necessary to define what is meant by critical thinking and how it can be developed within science education.

What is critical thinking?

Critical thinking is a skill that enables individuals to analyze information thoughtfully, evaluate arguments, and make evidence-based decisions. In science education, this skill is fundamental for students to interpret information and understand the problems affecting the world today. Science education is the pedagogical means to achieve scientific literacy,

empowering citizens to understand the natural world, make informed decisions, and develop critical thinking skills when faced with socio-scientific problems.

According to the Organization for Economic Cooperation and Development (OECD): “Scientific literacy involves actively participating in informed debates about science, sustainability, and technology to guide decision-making and action. This requires the ability to explain phenomena scientifically, design and evaluate scientific research, and critically investigate and interpret data and evidence.”

Critical Thinking in the Teaching of Natural Sciences

In 2002, SanMartí addressed the fundamental problem in science education: how to teach science in a meaningful way—that is, how to promote a scientific culture developed over centuries that can be understood by the general public. This involves answering questions such as: What should be taught? How should it be taught? When should it be taught? And how should the results be assessed? In his book *Science Pedagogy in Secondary Education**, he argues that: “To learn science, we need to change the ways we perceive phenomena, talk about them, reason, and even feel.” We do not want students to merely acquire knowledge about genetically modified organisms; rather, they should be able to analyze their consequences, make decisions, and contribute ideas to address them. Developing critical thinking in science education involves fostering skills in students such as analyzing scientific information, evaluating evidence, engaging in scientific argumentation, making informed decisions, and reflecting ethically on scientific advances. The use of socio-scientific problems facilitates the development of these skills, as it invites students to discuss, debate, and analyze different perspectives.

Socio-scientific problems in science education

According “An education that prioritizes only the memorization of concepts, without promoting scientific reasoning skills and attitudes, will hardly meet the objectives of full scientific literacy.” Socio-scientific problems are complex situations that involve scientific knowledge and also have social and ethical implications. According to (Ruiz, Solbes, & Furió Más, 2013), socio-scientific problems represent social dilemmas that are also influenced by factors related to scientific issues and are important to people’s lives. These problems often generate debate because they present multiple perspectives and possible solutions. In the educational context, their use helps connect scientific learning to real-

world situations, fostering a deeper understanding of the content and its relevance to everyday life.

Among the most commonly used socio-scientific problems in the teaching of natural sciences are climate change, biodiversity loss, deforestation, the use of genetically modified organisms, environmental pollution, the use of pesticides, energy privatization, and species conservation. Analyzing these topics helps students understand the relationship between science, society, and the environment.

“Environmental education does not advocate for particular opinions or procedures. Instead, it teaches individuals to weigh the different sides of an issue through critical thinking and fosters their own problem-solving and decision-making skills.” (U.S. Environmental Protection Agency (EPA), 2025)

Likewise, analyzing complex topics such as genetically modified organisms or environmental pollution encourages students to review data, identify biases, and distinguish between facts and opinions—but how do we achieve this in our classrooms?

Teaching Strategies for Addressing Socio-Scientific Issues in Natural Science Education

The incorporation of socio-scientific issues into the natural sciences teaching process can be achieved through various teaching strategies that encourage active student participation and critical analysis of reality. Among the most commonly used strategies are scientific debate, case studies, problem-based learning, and research projects, all of which allow students to address real-world situations from a scientific and reflective perspective.

Scientific Debate

Scientific debate is a pedagogical tool that promotes the exchange of ideas and reasoned argumentation among participants. In this regard, (Ortega Sánchez & Buzo Casan, n.d., p. 544) note that “debate is a form of formal and organized discussion characterized by the reasoned exchange of ideas and/or points of view between two or more people with opposing positions on a given topic.” Likewise, (Vásquez González, Pleguezuelos Saavedra, & Mora Olate, 2017) emphasize that “debate, in addition to contributing to the development of the ability to express ideas in a reasoned manner, fosters the development of critical thinking and requires the proper handling of information for its subsequent analysis, evaluation, and the formation of judgments based on criteria” (p. 135). When applied in the classroom, this strategy allows students to analyze different

perspectives on a socio-scientific problem and construct arguments supported by scientific evidence.

Case Studies

Case studies are another strategy widely used in education and research. According to (Jiménez Chaves & Comet Weiler, 2016), this approach has been the subject of debate within scientific research, although it has now become established as a common methodology in various fields of knowledge. Similarly, (Barrio del Castillo et al., n.d.) note that “the case study is a qualitative research method that has been widely used to gain an in-depth understanding of social and educational realities.” In an educational context, this strategy allows for the presentation of real-world situations related to environmental or biological issues that students must analyze. Based on this analysis, they can propose possible solutions, thereby strengthening both conceptual understanding and the development of critical thinking.

Problem-Based Learning

Problem-Based Learning (PBL) is a student-centered strategy in which a problematic situation is presented that requires investigation and analysis. In this process, students seek scientific information, compare different sources, and develop proposals to address the problem at hand. Furthermore, PBL is recognized as an educational strategy that, when carried out in a collaborative context, stimulates individual creativity and the ability to solve problems (Zhou & Navarro-González, 2025).

Research Projects

Research projects represent another teaching approach for addressing socio-scientific issues in the classroom. Through this strategy, students investigate environmental problems in their own surroundings, such as river pollution or the decline in local biodiversity. These types of activities foster a connection between scientific knowledge and the reality of the context in which students live.

Taken together, these strategies help create more participatory learning environments, where students not only acquire scientific knowledge but also develop the cognitive, social, and critical-thinking skills necessary to understand and address the challenges of today’s society.

Methodology

This study was conducted using a mixed-methods approach, combining a literature review with the collection and analysis of empirical data through a survey administered to 22 ISTUCED teachers.

In the first phase, a qualitative literature review was conducted. To this end, scientific articles, books, and academic documents related to the teaching of natural sciences, critical thinking, and the use of socio-scientific problems in education were reviewed.

In the second phase, a structured survey was administered to gather information on teachers' perceptions regarding the use of socio-scientific problems in natural science learning and their influence on the development of critical thinking. The instrument consisted of closed-ended questions designed to assess aspects such as the analysis of scientific information, argumentation, decision-making, and the relationship between science and society.

The study population consisted of ISTUCED teachers who teach courses related to the natural sciences. The sample was selected using non-probabilistic convenience sampling, taking into account the accessibility of the participating group.

The data obtained from the survey were processed using descriptive statistical analysis. The results were presented in tables and graphs, which allowed for an interpretation of the relationship between the use of socio-scientific problems and the development of critical thinking in students.

Finally, the results of the statistical analysis were compared with the information obtained from the literature review, which allowed us to draw conclusions about the relevance of this pedagogical strategy in the teaching of natural sciences.

Results

The results obtained for Question 1: "How often do you use socio-scientific problems in your science classes?" show that 50% of the teachers surveyed frequently use socio-scientific problems in their classes, while 45.5% indicate that they use them sometimes. Meanwhile, 4.5% indicated that they use them rarely, and no respondent reported never using them.

These results demonstrate that the majority of teachers recognize and incorporate, to varying degrees, socio-scientific problems into their teaching practice. The fact that 95.5% of respondents use them at least occasionally suggests a positive trend toward integrating this type of problem into the teaching of natural sciences. The high proportion of teachers who use them frequently suggests that there is a growing recognition of the educational value of socio-scientific problems as a strategy to promote a more reflective, participatory, and contextualized approach to science education.

Meanwhile, the data from Question 2—“What is the main purpose of using socio-scientific problems in science education?”—show that 40.9% of the surveyed teachers believe the main purpose is to develop critical thinking in students. Likewise, 22.7% of the participants indicate that the objective is to relate scientific theory to real-world situations, while another 22.7% state that the aim is to promote informed decision-making regarding scientific and social issues. Meanwhile, 13.6% of the teachers state that the main purpose is to foster scientific reasoning.

These results show that teachers perceive the development of critical thinking as the central objective of using socio-scientific problems in the teaching of natural sciences. This finding aligns with current approaches to science education, which suggest that discussing real-world problems with social, ethical, and environmental implications fosters reflection, the analysis of evidence, and the construction of well-founded arguments. Additionally, it suggests an understanding of natural science education as a process oriented not only toward the acquisition of knowledge but also toward the development of competencies for responsible participation in society.

When analyzing the results of Question 3: “What types of socio-scientific issues do you most frequently address in your classes?”, the results show that biodiversity conservation is the topic most frequently addressed by teachers, with 63.6% of the responses. In second place is public health (vaccination, epidemics), selected by 27.3% of the participants. To a lesser extent, teachers indicated that they cover topics related to climate change, biotechnology, and genetically modified organisms, each accounting for 4.5% of the responses.

These results suggest that teachers tend to prioritize socio-scientific issues related to the environment and health, possibly due to their high social relevance and their close connection to the natural science

curriculum. In particular, biodiversity conservation is a widely used topic in the classroom, as it allows for the exploration of ecological, ethical, and social aspects, in addition to promoting reflection on the impact of human activities on ecosystems. Furthermore, addressing public health issues reflects an interest in analyzing situations that have direct implications for the daily lives of students and society, which facilitates discussion, the analysis of scientific information, and the development of well-founded positions.

When asked, “What teaching strategy do you use most frequently when addressing socio-scientific issues?”, the results show that case studies are the most commonly used strategy among teachers, accounting for 54.5% of responses. In second place, classroom debates are used by 27.3% of participants, while group work and the study of scientific articles are used less frequently, at 9.1% each.

The results indicate that teachers tend to prioritize teaching strategies focused on the analysis of concrete situations, which is consistent with the nature of socio-scientific problems, which are often presented as complex cases or scenarios requiring the evaluation of evidence, the consideration of different perspectives, and informed decision-making. Likewise, the prevalence of classroom debates as the second most common strategy reflects the importance placed on opportunities for discussion and argumentation—fundamental elements for the development of critical thinking. Through the exchange of ideas, students can analyze scientific information, compare different viewpoints, and construct evidence-based arguments. Although to a lesser extent, collaborative work and the analysis of scientific articles are also relevant strategies, as they promote the interpretation of scientific information, collective discussion, and the participatory construction of knowledge.

In response to the question, “Do you believe that socio-scientific problems promote the development of critical thinking in students?”, the results show a highly positive assessment by the surveyed teachers. Specifically, 77.3% of participants believe that socio-scientific problems greatly promote the development of critical thinking, while 22.7% indicate that they promote it moderately. It is worth noting that no teacher selected the options “a little” or “not at all,” reflecting a general consensus on the educational potential of this approach.

These results demonstrate a broadly favorable perception toward the incorporation of socio-scientific problems into science education, as teachers recognize their contribution to strengthening higher-order

cognitive skills. Analyzing these types of problems involves evaluating scientific information, considering different perspectives, and constructing well-reasoned arguments—all of which are fundamental to the development of critical thinking. This reinforces the idea that socio-scientific problems constitute a relevant teaching tool for promoting critical thinking and scientific literacy by linking scientific knowledge to social situations that are relevant and close to students' reality.

In the analysis of the results for Question 6—"What skills do you observe being developed in students when analyzing socio-scientific problems?"—the results show that the majority of teachers (59.1%) believe that analyzing these types of problems contributes to the simultaneous development of multiple skills, including scientific argumentation, information analysis, and evidence-based decision-making. Furthermore, 18.2% of participants specifically identify the development of scientific reasoning as one of the main skills strengthened in students. Similarly, another 18.2% note that informed decision-making is promoted, while 4.5% consider information analysis to be the primary skill developed.

These results suggest that socio-scientific problems promote the integrated development of various cognitive competencies related to critical thinking. In particular, the analysis of scientific issues with social implications requires students to interpret scientific information, evaluate evidence, construct arguments, and make decisions based on well-founded criteria.

Question 7 asks: "What difficulties do you encounter when integrating socio-scientific problems into the science classes you teach?" The responses from the interviewed teachers show that the main difficulties identified by teachers are related to a lack of teacher training on the subject and low student interest, each accounting for 31.8% of the responses. Second, 27.3% of the participants cited a lack of time in the curriculum as a limitation to incorporating socio-scientific issues into their classes. Finally, 9.1% of the teachers indicated that a shortage of teaching resources constitutes a difficulty when addressing these types of issues in the classroom.

These results suggest that the barriers to implementing socio-scientific problems in science education are primarily related to instructional and motivational factors, rather than to the availability of materials or resources. The perception of low student interest may be linked to the

way these issues are presented or addressed in the classroom, highlighting the importance of designing pedagogical strategies that connect scientific content to situations relevant to students' real lives. A lack of time within the curriculum also emerges as a significant factor, highlighting the challenges teachers face when attempting to integrate innovative pedagogical approaches into structured educational programs. Taken together, these results highlight the need to strengthen teacher training and promote teaching strategies that facilitate the integration of socio-scientific problems into science education, in order to harness their potential for developing critical thinking and scientific literacy among students.

When asked, "At what point in the teaching process do you typically integrate socio-scientific problems?", the majority of teachers (54.5%) indicated that they incorporate them while covering the lesson content, suggesting that they are used primarily as part of the process of constructing and deepening scientific knowledge. Likewise, 31.8% of respondents indicated that they use them as an activity for analysis or debate, which demonstrates their use as a strategy to promote discussion, reflection, and argumentation regarding scientific issues with social implications. On the other hand, 13.6% of teachers indicated that they use them for assessment or as a final reflection on the learning process. It is worth noting that no participant selected the option of using them at the beginning of class as a motivational strategy, which could indicate that their integration is geared more toward the analysis and in-depth exploration of scientific content, as well as toward critical reflection following the development of the topic.

Taken together, these results show that socio-scientific problems are primarily integrated during the central stages of the teaching-learning process, where they can facilitate the analysis of information, the discussion of different perspectives, and the construction of well-founded arguments. In this way, their incorporation helps promote reflective and critical thinking among students, strengthening a more contextualized and participatory approach to science education.

In response to the question: "How well-prepared do you think teachers are to address socio-scientific problems in the classroom?", half of the respondents (50%) believe that teachers are poorly prepared to address this type of issue in the classroom. On the other hand, 40.9% of participants indicated that teachers are moderately prepared, while only 4.5% believe they are very well prepared. Similarly, 4.5% of respondents believe that teachers are not at all prepared to address socio-scientific issues in science education.

These results reveal a general perception of limited preparedness among teachers to integrate socio-scientific issues into their teaching practice. Although a significant proportion believes there is a moderate level of preparedness, the fact that the majority perceives this preparedness as insufficient suggests the need to strengthen teacher training programs in instructional strategies focused on analyzing scientific issues with social implications. Furthermore, these findings align with the difficulties highlighted in previous questions regarding the lack of teacher training on this topic, reinforcing the idea that the effective implementation of socio-scientific issues in the classroom requires additional training, pedagogical updates, and access to specific teaching guidelines. In this regard, the results highlight the importance of promoting continuing education programs and opportunities for professional development for teachers, which enable educators to acquire methodological tools to effectively integrate socio-scientific problems into science instruction and, in this way, foster the development of critical thinking in students.

The final question in the survey asks: “Based on your experience, does the use of socio-scientific problems in science education primarily contribute to...?” The majority of teachers (68.2%) believe that their use contributes simultaneously to several aspects of learning, including understanding scientific content, the relationship between science and society, and the development of critical thinking in students. Likewise, 18.2% of participants indicated that the main contribution is linking science to society, which demonstrates recognition of the value of these problems in contextualizing scientific knowledge and analyzing its social implications. On the other hand, 13.6% of teachers indicated that the main contribution is the development of critical thinking in students. It is worth noting that no participant selected the option “better understanding of scientific content” as the sole contribution, suggesting that teachers perceive the use of socio-scientific problems as a comprehensive pedagogical strategy that goes beyond the simple transmission of content, fostering more contextualized and reflective learning.

Taken together, these results show that teachers recognize the educational potential of socio-scientific problems to promote science education that is more closely connected to social reality, as well as to foster complex cognitive skills, such as critical analysis, argumentation, and informed decision-making. Thus, their incorporation into the

classroom helps strengthen scientific literacy and the development of citizens capable of understanding and critically analyzing the scientific and technological challenges of contemporary society.

Conclusions

The research findings show that socio-scientific problems constitute a relevant teaching strategy for promoting the development of critical thinking in the teaching of natural sciences. Most of the teachers surveyed acknowledge that analyzing these types of problems allows students to reflect on real-world situations related to science, society, and the environment.

The data obtained show that teachers use socio-scientific problems relatively frequently in their classes, primarily when covering content and through strategies such as case studies and classroom debates. These pedagogical practices foster information analysis, scientific reasoning, and informed decision-making—skills that are fundamental to the development of critical thinking.

Furthermore, the results indicate that teachers perceive the use of socio-scientific problems as simultaneously contributing to students' understanding of scientific content, their understanding of the relationship between science and society, and the strengthening of critical thinking. This demonstrates that their implementation enables a more contextualized and meaningful science education.

However, the study also identifies limitations to their integration into the classroom, notably the lack of teacher training in addressing these types of issues, limited time within the curriculum, and, in some cases, the perception of low student interest. These aspects highlight the need to strengthen teacher training processes and promote pedagogical strategies that facilitate the incorporation of this approach into science education.

In summary, the results lead to the conclusion that incorporating socio-scientific problems into science education fosters the development of critical thinking, scientific reasoning, and informed decision-making, thereby contributing to the development of students capable of understanding and analyzing the scientific and social challenges of the contemporary world.

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