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# RISK MANAGEMENT INTEGRATED WITH ENVIRONMENTAL EDUCATION AND THE APPLICATION OF FUZZY LOGIC

## *GESTÃO DE RISCO INTEGRADA À EDUCAÇÃO AMBIENTAL E A APLICAÇÃO DA LÓGICA FUZZY*

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**Abstract**
Understanding environmental education requires the sequential and historical interconnection of understanding education in its genesis and continuous and progressive formulation in the West. This article explores the configuration of environmental education in order to place it in the risk society, taking into account the existing problems and complexities. The configuration and contextualization applied to risk management integrated with environmental education were analysed based on the critical propositional method. This article argues for the inability of binary models to respond or support risk management.

***Resumo***
*A compreensão da educação ambiental demanda a interligação sequencial e histórica de compreensão da educação em sua gênese e formulação contínua e progressiva no ocidente. Este artigo labora com o percurso configurador da educação ambiental de modo a situá-la na sociedade de risco, tendo em conta as problemáticas e complexidades existentes. A partir do método crítico-propositivo, analisa-se a configuração e contextualização aplicada da gestão de risco integrada à educação ambiental. O artigo sustenta a incapacidade de modelos binários para fins de resposta ou suporte à gestão de risco. Articula-se em conclusão e proposição a aplicação da lógica fuzzy*

The application of fuzzy logic is articulated in the conclusion and proposition for the purposes of formulating and implementing risk management, considering the complicated situations of the risk society. In this way, components such as uncertainty, indeterminacy and cloudiness are not ignored, but internalized in risk management.
**Keywords:** environmental education; fuzzy logic; risk management.

*para fins de formulação e implementação da gestão de risco, considerando vicissitudes da sociedade de risco. Dessa forma, componentes tais como incerteza, indeterminação e nebulosidade não são ignoradas, mas, sim, interiorizadas na gestão de risco.*
***Palavras-chave:*** *educação ambiental; gestão de risco; lógica fuzzy.*

## Introduction

Education is one of the ways that man has found to achieve better socialization among human beings. If it often fails to achieve its objective, this is due to the inherent complexity of human relationships. Even so, it plays a fundamental role in humanity's journey.

Based on this assumption, this article aims, initially, to show the relevance of education in the constitution of the human being, in addition to presenting a brief history of education and its ability to generate a critical sense in individuals.

Subsequently, the article relates the previous concept with environmental education, presented as an element that is part of the history of education, and which has become fundamental in the contemporary world, which is understood as a guarantor of a critical environmental sense, helping to safeguard the planet. This will be based on the analysis of fundamental documents for the creation and consolidation of environmental education, including Brazilian legal texts.

The article goes on to relate environmental education to integrated risk management, showing that its inherent complexity and its multi- and transdisciplinary content can contribute to overcoming a binary view of risk management.

In order to support the notion presented, fuzzy logic will be applied, bringing elements such as uncertainty, cloudiness, and indeterminacy to the analysis of risk management.

The article has a critical-propositional methodology, with an interdisciplinary view of Environmental Law, aligning theoretical and practical aspects in order to overcome epistemological reductionism. This will be done through a bibliographical review and analysis of texts from the philosophical, educational, legal, and logical areas, in order to justify environmental education in environment-related issues.

## 1 A brief history of education and its importance for critical sense

Since the Greeks, the question about *paideia*, which can be understood as education, has become fundamental to human existence. Education, at least in theory, is presupposed to be something that makes the individual more human. This is how Peter Sloterdijk, in Rules for the Human Zoo: A Response to the Letter on Humanism, interprets the entire humanist tradition: "What from Cicero's time onward has been called *humanitas* belongs, in the narrowest and broadest sense, to the consequences of literacy" (Sloterdijk, 2000, p. 7, emphasis added).

Education has become a way of being and understanding what it is to be human. Throughout human history, education has been a link between different generations, whose main purpose is to tame the brutalizing forces of the human being and perpetuate humanity (Sloterdijk, 2000).

This provocative reading becomes clearer now that humanity and its destructive forces are endangering the planet and the species that exist on it, including humans, "in line with what Freud called the drive to destroy, which needs to be curbed when one intends to defend the environment and thus guarantee life" (Reis; Vieira, 2017, p. 5; our translation).

The history of formal educational training is thousands of years old. Before delving into environmental education as a contemporary creation, a summary of formal education will be presented.

In this regard, before Western philosophy focused on education, it is possible to refer to teaching in other ancient traditions. In this sense, we can mention the ascetic-therapeutic school of Buddha (650 BC – 550 BC), created in India, which aimed to purify and free disciples from pain (Ulmann, 2000).

In China, it is important to highlight the ethical-religious school of Confucius (511 BC – 478 BC), whose mottos were "the reform of customs, love of neighbor, filial piety, contempt for wealth and worldly glories" (Ulmann, 2000, p. 84).

The first prominent Greek school as far as education is concerned is the Pythagorean school, founded by Pythagoras (582 BC – 500 BC). With religious and moral teachings, the disciples lived in community, celibately, in silence, without eating certain foods and making a daily examination of conscience. They also believed in the transmigration of the soul and kept the master's teachings secret (Ulmann, 2000).

Plato (428/27 BC – 348/47 BC), one of the great Western educators, illustrates the importance of personal training in several of his works. The Athenian

thinker believed so much in education that he created his own school in his city, in 387 BC, which would become known as the Academy[1]. At school, dialectics, physics, and ethics were taught, as well as mathematics, music, and astronomy. He made a distinction between *episteme*, true science based on rationality, and *doxa*, vulgar opinion that was based on the senses (Ulmann, 2000).

The former student of the Academy, Aristotle (384 BC – 322 BC), also created another school, called the Lyceum, also known as Perípato[2]. Given the encyclopedic interest of the Macedonian thinker, at school they studied logic, metaphysics, meteorology, zoology, botany, psychology, morals, rhetoric, poetry, etc. (Ulmann, 2000).

The Hellenistic currents, Epicureanism and Stoicism, also created important schools in Athens, known, respectively, as the Garden of Epicurus (341 BC – 270 BC), and the Portico, created by Zeno of Citium (340 BC – 263 BC), which will have its foundations spread across various parts of the Hellenistic and later Roman world (Ulmann, 2000).

Still in antiquity, in the city of Alexandria, the Mouseîon (gathering of muses) was founded by King Ptolemy I (323 BC – 285 BC), who, in a way, transferred the title of great educational city from Athens to Alexandria. At the Mouseîon, mathematics, astronomy, geography, medicine, historiography, literature, and humanities were studied[3] (Ulmann, 2000).

Also in Alexandria, in the 2nd and 3rd centuries of the Christian era, Dydascalia (*Didaskaleion*) was founded, influenced by Platonic and Stoic elements and by Philon of Alexandria (20 BC-50 AD), and which would include authors such as Panteno (120-180), Clement (150-215), and Origen (185-254), well-known defenders of Christianity. This was the combination of Greek philosophy with Christian teachings (Ulmann, 2000), the foundations of Western culture.

In 425, the school of Constantinople was founded by Theodosius II (401 – 450)[4] in Constantinople, with the aim of refuting pagan culture. Teachers were paid by the state and taught grammar, Latin, Greek, philosophy, rhetoric, law,

1 The school founded by Plato got its name because it was located in a park in honor of the hero Academus (Reale, 1997, p. 8).

2 Aristotle founded his school in some rented buildings, close to a temple dedicated to Apollo Lycius. The name Perípato comes from the Greek *peripatos*, which means walk, as Aristotle taught while walking around the place (Reale, 1997, p. 316).

3 It should be noted that: "Among the Alexandrian scientists, we highlight Eratosthenes (276 BC – 194 BC), who calculated the circumference of the earth with a margin of error of 384 km. In medicine, we can highlight Praxagoras, who was the first to dissect human corpses" (Ulmann, 2000, p. 90, note 37; our translation).

4 About Theodosius II: "Theodosius II published the famous *Codex Iustinianus*, which constitutes the foundation of Roman-Christian legislation. It encompasses all the laws in force, including issues related to religious life and heresies" (Ulmann, 2000, p. 92, note 46; our translation).

and theology. It had several characteristics that would be practiced by medieval Universities (Ulmann, 2000).

In 970/72, Al-Azhar, an important school in Cairo, Egypt, was created. It also contained several elements that will be present in the Western medieval university. It was created by the vizier Yaqub ibn Killis (930 – 991), so that the Caliph Abu Mansur Nizar al-Aziz Billah (955 – 996) could teach 35 students from the Al Azhar Mosque. Its initial concern was theological training, but over time it added various students and subjects to its teachings (Ulmann, 2000).

The Middle Ages saw the founding of universities, a model of higher education. Some reasons can be listed for this event: (a) consolidation of cities with their increase in population and students; (b) the crusades and, consequently, contact with other cultures; (c) the interest of emperors and Popes in intellectuality; (d) the limit of traditional knowledge represented by the *trivium and quadrivium*[5]; (e) associations created by teachers and students called *universitas*, a name already used by other corporations such as merchants; (f) the creation and union of different courses in the same space (even though places with only one course were also called *universitas*); (g) the coming and going of students and teachers from all social classes and European countries to study and teach, with the aim of (inner) spiritual elevation; (h) the congregation of different individuals (clergy or lay people); and (i) the political interests of Popes and rulers towards a given region. Universities emerged in Bologna, Paris, and Oxford, considered by tradition to be the first three. From there, institutions would be consolidated throughout Europe (Ulmann, 2000).

Until the arrival of the industrial era, literacy rates were very low. In the Middle Ages, the proportion in some locations reached a maximum of 10%, which would gradually change from the 16th century onwards, thanks to technological advances and trade, as Galor explains (2023).

But it is with industrial societies, from the 19th century onwards, that education will become universal, with the "provision of public education predominantly because they realized the importance of general mass education in a dynamic technological environment, both for business owners and for the workers themselves" (Galor, 2023, p. 93). Industrialists began to lobby, along with parents and children, for national states to increase spending on formal education, in order to train specialized workers. By the early 20th century, due to technological advances, several of the first industrialized nations had almost 100% of their adults

5 The *trivium* was composed of the following subjects: logic, grammar, and rhetoric. The *quadrivium* was composed of arithmetic, music, geometry, and astronomy.

literate, which increased workers' wages and eliminated child labor (Galor, 2023).

With the consolidation of National States, the rise of the bourgeoisie, the theoretical notions that the formation of an adult depends on their childhood, education will be consolidated in contemporary times as a fundamental right, guaranteed by laws. In the Brazilian case, it is guaranteed by the Federal Constitution itself as a social right, as can be seen in Art. 6:

> Education, health, food, work, housing, transportation, leisure, security, social security, protection of motherhood and childhood, and assistance to the destitute, are social rights, as set forth by this Constitution. (Brasil 1988).

Thus, education encompasses all aspects of human life. In comparison with other social rights, it is possible to say that education is a fundamental step towards having health, food, work, housing, leisure, security, social security, as well as enabling a decent motherhood and childhood. A person who has an educational background is a person who can acquire critical sense and seek out their other rights. But what is critical sense?

Plato's (2006) words on critical sense are perhaps paradigmatic. The "myth of the cave", found in book VII of *The Republic,* is perhaps one of the best-known excerpts of Western thought. In it, Plato recounts that some human beings lived trapped in a cave, seeing only shadows reflected on the wall, which they think are the only forms of reality. One of these individuals frees himself and heads towards the cave's entrance. At the entrance he notices other human beings outside, carrying artifacts in their hands. These artifacts (the first seen after the individual breaks frees) are lit by a fire and reflected into the cave, creating shadows on the wall. On leaving the cave, the individual realizes that his eyes cannot see clearly because of the brightness, which he was not used to.

Thus, the first things he can see are objects reflected in the water. As he adapts a little more to his new situation, he is able to perceive the "real" things in nature that he had previously seen in the reflection of the water. At dusk, he sees the moon and the stars. Finally, the next day, he sees the sun itself, capable of illuminating everything else. Realizing his discovery, he decides to return to the cave and tell his companions, who, hearing his story, decide to rebel against him.

This story, perhaps the greatest philosophical intuition of Western thought, has been and continues to be interpreted in different ways. A pertinent interpretation is to associate it with the notion of critical sense. In this respect, inside the cave can symbolize a place where human beings do not have any "critical sense", as they only know the reflected shadows. The outside of the cave is the place where one can acquire some "critical sense", as there is a reality to compare with the

shadows inside the cave. Each human being has the option of remaining outside the cave or returning to it.

The first thing to ask is: Is it better to stay inside or outside the cave? Perhaps having a "critical sense" is ideal, as no one wants to be "fooled" all the time, but by taking this stance one runs the risk of being excluded by those who continue to see shadows, as it happens in the Platonic narrative.

The search for "critical sense" requires time to transform information into knowledge, in other words, education and training must be pursued. However, many people spend most of their time busy with routine activities that hinder reflection. How can you leave the cave when you are "forced" to remain inside it for reasons "beyond" you?

Perhaps two questions complement each other: to what extent does leaving the cave depend on one's own will and to what extent does it depend on the environment in which one lives? It is possible to affirm a relationship between will and opportunities to gain a critical sense. It is naive to place all the responsibility for gaining a critical sense on the individual will, making the inconsequential relationship, in this case, between will and power. Also, placing any possibility of gaining a critical sense in the environment would be tantamount to abdicating one's own responsibilities along the way.

Some of these "inhabitants" can be seen throughout life. There are those, perhaps the majority, who think they have always been outside the cave and consider everyone else to be the inhabitants of the cave. There are those who are aware of the existence of the outside of the cave, and yet want to remain inside, which represents the most comfortable situation! Some consider the cave to be the only reality. And then there are those who want to get out the cave but cannot—the most tragic situation!

In short, the search for critical sense inevitably involves education. Therefore, the other social rights listed are more likely to be realized from this first social right. Knowing one's rights is the first step towards acquiring citizenship.

In the case of environmental education, it is also a question of the permanence of the planet itself and the survival of the beings that inhabit it, which, through critical thinking, can help to mitigate the destructive instincts of human beings.

## 2 A path to environmental education: from Stockholm to Tbilisi

Environmental education can be presented as a view that behaviors

and customs should be geared towards preserving planet Earth, aiming for an ecologically balanced environment.

The term *environmental education* first appears at the Keele University Education Conference, in 1965 (Czapski, 1998). An important way of understanding environmental education is by reviewing some official documents that consolidated it as a fundamental training for individuals, societies, and States. There are four fundamental documents, which will be analyzed below, and which deserve to be highlighted: (1) *Report of the United Nations Conference on the Human* Environment (1972); (2) *The Belgrade Charter: a framework for Environmental Education* (1975); (3) *Declaration of the Intergovernmental Conference on Environmental Education* (1977); and (4) *International Congress on Environmental Education and Training* (1987).

One of the first documents on the environment, at a global level, the United Nations Declaration on the Human Environment, which is found in the *Report of the United Nations Conference on the Human Environment,* from the *Conference on the Human Environment* in Stockholm, 1972, highlights that

> To achieve this environmental goal will demand the acceptance of responsibility by citizens and communities and by enterprises and institutions at every level, all sharing equitably in common efforts. Individuals in all walks of life as well as organizations in many fields, by their values and the sum of their actions, will shape the world environment of the future. Local and national governments will bear the greatest burden for large-scale environmental policy and action within their jurisdictions (United Nations, 1973, p. 3-4).

The document, which will become known as the Stockholm Declaration, will serve as a basis for reflection and practices on environmental preservation, as well as being taken as a guideline for thinking about environmental training, which has the citizen as the protagonist, but which fundamentally depends on States to become effective.

In its Principle 19, the Declaration emphasizes the need for education focused on the environment:

> Education in environmental matters, for the younger generation as well as adults, giving due consideration to the underprivileged, is essential in order to broaden the basis for an enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human dimension (United Nations, 1973, p. 5).

Environmental education aims to disseminate knowledge and values to promote behaviors and develop the skills necessary to participate ethically and

effectively in the prevention and search for solutions to the problems regarding life on planet Earth, ensuring the quality of the environment. It will be understood as a formative element for human responsibility towards the environment.

In its Recommendation 96 of the aforementioned document, the UN (United Nations, 1973) suggests the establishment of an international program in environmental education, which has an interdisciplinary approach, and which covers education at all levels, containing in its program: (1) a survey of training courses that include environmental education; (2) an exchange of information between environmental education training courses, with due dissemination of teaching experiences; (3) adequate training for those who deal with environmental education; (4) formation of interdisciplinary groups, so that professionals can exchange experiences in their respective areas; and (5) development of methods and materials appropriate to environmental education at different levels of training.

It can be stated that these first UN guidelines and suggestions regarding environmental education will serve for subsequent reflections and practices.

In 1975, the United Nations, through its Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Program (UNEP) promoted the International Environmental Education Meeting in Belgrade, former Yugoslavia, currently Serbia, where it proposed a new global ethics, which would have environmental education as the main point of this new stance, through the International Environmental Education Program.

The inspiration for the event was Recommendation 96 of the Stockholm Human Environment Conference, already highlighted previously. But the event in Belgrade was more specific toward environmental education, with the main purpose to seek a dignified life for present and future generations (Unesco-Unep, 1975).

The text *The Belgrade Charter: a framework for Environmental Education*, the result of the meeting, contains the following goal for environmental education:

> The goal of environmental education is to develop a world population that is aware of, and concerned about, the environment and its associated problems and which has the knowledge skills, attitudes, motivations, and commitment to work individually and collectively towards solutions to current problems, and the prevention of new ones (Unesco-Unep, 1975, p. 3).

What the text calls "being aware of" is what has previously been called critical sense, which has the role of transforming the individual not only theoretically but also practically, with a view to dealing well with the environment individually and collectively.

Another relevant point of the document (Unesco-Unep, 1975) is the explanation, for individuals and the community, of the objectives of environmental education, which would be: (1) awareness of environmental problems; (2) knowledge about the environment, its problems and the relationship between human beings and nature; (3) attitude that allows active participation in protecting the environment; (4) skills that provide solutions to environmental problems; (5) ability to evaluate the measures to be taken regarding the environment, as well as the relationship between education and ecological, political, economic, and aesthetic aspects; and (6) participation through responsibility and action with regard to environmental problems.

Finally, it is important to highlight the guiding principles of environmental education present in the charter (Unesco-Unep, 1975), which will serve as a basis for future reflections: (1) consider the environment in all its dimensions (natural, artificial, ecological, political, economic, technological, social, legislative, cultural, and aesthetic); (2) be a continuous process inside and outside the formal school environment; (3) be interdisciplinary; (4) emphasize active participation in the prevention and resolution of environmental issues; (5) be global and regional; (6) turn to present and future issues; (7) have an environmental perspective on all issues; and (8) promote local, national and regional cooperation in the search for environmental solutions.

In 1977, again, UNESCO and UNEP held the Intergovernmental Conference on Environmental Education in Tbilisi[6], in the former Soviet Union, currently Georgia. In the official document, *Intergovernmental Conference on Environmental Education* (Unesco-Unep, 1978), you will find the *Declaration of the Intergovernmental Conference on Environmental Education*, which contains 41 recommendations regarding environmental education, becoming a reference text for environmental education. Among the recommendations, it is important to highlight some that make important contributions to environmental educational guidelines.

In Recommendation 1, for example, UNESCO-UNEP (1978) recommends that Environmental Education, in addition to biological and physical bases, is also related to sociocultural, economic, and ethical dimensions. Here we also find the

6 A curiosity about the event: "What about Brazil, at this event? It was not present, at least in an official capacity. The justification is, to say the least, curious: according to Regina Gualda, who at that time was the head of the Communication and Environmental Education Division of the Special Secretariat for the Environment of the federal government, our country did not maintain diplomatic relations with the Soviet bloc, which prevented the participation. And, even after the event, several years passed before Brazilians had access to the 1977 documents, initially through some titles on the publishing market" (Czapski, 1998, p. 30; our translation).

notion that environmental education must be given to the general public, to social groups and to scientists and technicians, implying the need to cover all citizens.

In Recommendation 2 (Unesco-Unep, 1978), in turn, the purposes of environmental education are presented, which are: (1) to show the relationship between economic, social, political, and ecological aspects, in the city and in the countryside; (2) offer knowledge so that individuals can better deal with the environment; and (3) propose new standards of conduct for individuals and society regarding the environment.

Recommendation 3 (Unesco-Unep, 1978) proposes to Member States: (1) make environmental education a public policy; (2) disseminate environmental education to citizens; 3) instill environmental education in children, even before compulsory education, through families; (4) place great responsibility for environmental education on formal education (primary and secondary); (5) increase the number of higher education courses related to the environment; (5) provide continuous theoretical and practical training in environmental issues; (6) instill a sense of environmental responsibility in its citizens; and (7) foster an ethic of respect for nature and present and future human beings.

Recommendation 7 (Unesco-Unep, 1978) insists on the importance of training specialists in environment-related issues, as well as the fundamental development of school programs, consultation materials, and pedagogical methods to aid environmental training. And that this should be done, as Recommendation 12 shows, through environmental education that cuts across the various training disciplines and takes into account local and interdisciplinary aspects. In this training, as Recommendation 13 illustrates, higher education schools play a fundamental role, as they are centers for training and dissemination of knowledge, and should stimulate research, the creation of teaching material, and interdisciplinary training, preferably through a network between institutions. Recommendation 17 also emphasizes the need for environmental training for teachers in all fields, so that they can deal with environmental issues from their own field; and for teachers who have not had this training, Recommendation 18 states that the State must provide complementary training in environmental education.

Recommendation 20 (Unesco-Unep, 1978) instructs that environmental education is not exclusively associated with formal (university) education, but should be present in individuals' daily lives through: (1) government educational campaigns; (2) formal and non-formal environmental education programs; (3) the execution of environmental campaigns through NGOs; (4) UNESCO's participation in actions by UN Member States; and (5) the use of museums and

exhibitions to raise awareness among the general public.

It is important to emphasize that environmental education, as a process in construction of citizenship, is related to the concept of developing ecocitizenship, which is part of the notion of environmental education as a key factor in building citizenship, which aims to do make individuals and communities understand the complexity of nature, and its different biological, cultural, physical, social, economic, and philosophical aspects.

The complexity of the environment requires pedagogical models adapted to each place, city, or habitat where living beings live in symbiosis with nature and its resources, while at the same time it is a challenge for the planet and for each particular culture, people, nation, ethnicity, and language. In this sense, the local and the universal must be thought of together in environmental education.

In 1987, in Moscow (USSR), UNESCO and UNEP organized the *International Congress on Environmental Education and Training*, in which they sought to evaluate what had happened in the last 10 years since the event in Tbilisi, and to prepare strategies for the consolidation of environmental education in UN member countries (Unesco-Unep, 1988). The document is heavily based on the guidelines proposed in Tbilisi, but can be summarized in the following guidelines:

1. Access to information: facilitate access to information, based on strengthening the international information system and exchange of experiences of the International Environmental Education Program (IEEP);
2. Research and experimentation: reinforce research and experimentation with educational content and methods and strategies for organizing and transmitting messages about the environment, education, and training;
3. Education programs and teaching materials: promotion of environmental education through the development of curricular and pedagogical materials for general education;
4. Training personnel: promotion of initial and ongoing training of qualified personnel in formal and non-formal environmental education;
5. Technical and vocational education: incorporation of an environmental dimension into technical and vocational education;
6. Educate and inform the public: educate and inform the public more effectively about the environment through the use of the media and new communication and information technologies;
7. General university education: more effective incorporation of the environmental dimension into general university education, through the development of study programs, teaching materials and training and the establishment of appropriate institutional mechanisms;

8. Specialized training: promote specialized scientific and technical environmental training;
9. International and regional cooperation: development of environmental education through coordinated international and regional cooperation.

Information, research, education, training, and cooperation are the focuses that the document presents in relation to environmental education. In a certain way, these axes will appear in proposals on environmental education.

## 3 The formalization of environmental education in Brazil and its integration into risk management

After the UN conferences and documents, in the events of 1972, 1975, and 1977, Brazil began to worry about environmental education. A first move in this direction was the creation of the Special Secretariat for the Environment (*Secretaria Especial do Meio* Ambiente – SEMA), with Decree No. 73,030, of October 30, 1973, which in Art. 4, i, states that SEMA is responsible for: "intensely promoting, through programs on a national scale, the clarification and education of the Brazilian people in the appropriate use of natural resources, with a view to conserving the environment" (Brasil, 1973; our translation)[7].

In the following years, isolated events involving environmental education will take place, but these will still not be enough to consolidate it in Brazil[8]. This

7 Sema was important for the first attempts to apply Environmental Education in Brazil: "In 1976, SEMA signed an unprecedented agreement with the Educational Foundation of the Federal District and the University of Brasília, to facilitate the first Extension Course for Primary School Teachers in the Federal District, in which more than training teachers, the proposal was to reformulate the curriculum in schools in the Federal District in the field of physical and biological sciences, with the introduction of environmental themes, in a focus that prioritized the individual and the environment. […] The success of the work inspired the Ceilândia Project, started in 1977 in this satellite city of Brasília" (Czapski, 1998, p. 38).

8 It is important to highlight the following events:
1) In 1977, SEMA created a Working Group with the purpose of producing a document that defines the role of Environmental Education;
2) In 1979, the Secondary Education department of the Ministry of Education and Culture (MEC), together with the Environmental Company of the State of São Paulo (CETESB), published the document Ecology – a proposal for primary and secondary school education, which consisted of teaching material to address environmental issues in public schools.
3) The constitution of Law no. 6,938, of August 31, 1981, which implemented the National Environmental Policy, in its Article 2, X, and described the following principle: "environmental education at all levels of education, including community education, aiming to enable it for active participation in the defense of the environment" (Brasil, 1981; our translation).
4) In 1985, the MEC issued Opinion 819/85, which emphasizes the relationship between ecological content and all areas of knowledge, which aimed to form an ecological awareness among primary and secondary school students.
5) In 1986, SEMA launched its first specialization in Environmental Education.
6) In 1987, the Federal Council of Medicine, through Opinion 226/87, approved the inclusion of

will be proposed from the Brazilian Constitution of 1988 onwards.

Art. 225 of the 1988 Federal Constitution already contains the importance of environmental education as a fundamental element for the preservation of the environment:

> Art. 225. All have the right to an ecologically balanced environment, which is an asset of common use and essential to a healthy quality of life, and both the Government and the community shall have the duty to defend and preserve it for present and future generations.
> § 1. In order to ensure the effectiveness of this right, it is incumbent upon the Government to:
> I – […]
> VI – promote environment education in all school levels and public awareness of the need to preserve the environment; (Brasil, 1988).

Eleven years after the 1988 Constitution, Law no. 9,795, dated April 27, 1999, provides for environmental education, establishes the National Environmental Education Policy and provides other measures. Art. 1 defines environmental education as:

> the processes through which the individual and the community build social values, knowledge, skills, attitudes and competencies aimed at conserving the environment, an asset for the common use of the people, essential to a healthy quality of life and its sustainability (Brasil, 1999; our translation).

It can be seen that the article is in agreement with Art. 225 of the 1988 Federal Constitution, bringing the concept of sustainability as a novelty. The understanding of environmental education as a builder of values and skills also takes up Principle 19 of the Stockholm Declaration.

The aforementioned Law, in its Art. 3, emphasizes that environmental education must be disseminated: (1) by the Public Authorities; (2) by educational institutions; (3) by the bodies that are part of Sisnama[9] (National Environmental System); (4) through the media; (5) by companies, trade associations and public and private institutions; and (6) by society in general (Brasil, 1999).

Based on the understanding that environmental education must be present in all social spheres and among its various actors, in accordance with the

Environmental Education, through interdisciplinary training in school curricula, and encouraged the creation of Environmental Education Centers (Czapski, 1998).

9 Article 6 of Law No. 6,938, of August 31, 1981 reads: "The bodies and entities of the Federal Government, the States, the Federal District, the Territories and the Municipalities, as well as the foundations established by the Public Authorities, responsible for the protection and improvement of environmental quality, will constitute the National Environmental System – SISNAMA" (Brasil, 1981; our translation).

guidelines presented at UN/UNESCO events, the presidential decree enforces this perspective. Art. 7 also illustrates this involvement of society in general when, on the creation of the National Environmental Education Policy, it states that its implementation is carried out by

> […] bodies and entities that are part of the National Environmental System – Sisnama, public and private educational institutions in the school systems, public bodies of the Federal Government, the States, the Federal District and the Municipalities, and non-governmental organizations operating in environmental education (Brasil, 1999; our translation).

Regarding the National Environmental Education Policy, Art. 8 states that it is the role of general and school education to be concerned with: (1) training human resources; (2) developing studies, research, and experiments; (3) producing and disseminating educational material; and (4) monitoring and evaluation (Brasil, 1999). These elements can be found, as seen, in the document from the International Congress on Environmental Education and Training, produced by UNESCO-UNEP (1988).

Also influenced by UN documents (UNESCO-UNEP), Law No. 9,795/99 legislates on environmental education in the formal educational environment, whose main objective is that environmental education is, in accordance with Art. 10 "developed as an integrated, continuous and permanent educational practice at all levels and types of formal education" (Brasil, 1999; our translation). This means that environmental education should be present from basic to higher education, preferably being a crosscutting course of study.

The legislator also sought to regulate the importance of environmental education for teachers so that the environmental dimension would be included in their training curricula covering all levels and across all subjects, according to article 11 of the same law. As for active teachers, it is recommended that they receive "complementary training in their areas of activity, with the purpose of adequately meeting the principles and objectives of the National Environmental Education Policy" (Brasil, 1999; our translation).

On the other hand, environmental education must also be present in non-formal education, which, according to Art. 13, is defined as "educational actions and practices aimed at raising public awareness of environmental issues and their organization and participation in defending the quality of the environment" (Brasil, 1999; our translation), which involves other sectors of society[10]. In accordance with the aforementioned Law, it is important to remember the concept of environmental education as understood by the Brazilian government

10 Decree no. 4281/2002 regulates Law no. 9,795/99 and provides for environmental education and the establishment of national environmental education policies.

in the spirit of the international Conventions and the basic guiding principles of the educational process in question, being a fundamental right to which everyone is entitled.

The applied aspects of environmental education are therefore not aimed at a critical closure or imprisonment, but rather at critically understanding social reality in the development of awareness capabilities, construction and reconstruction of knowledge matrices, the applied expression of skills in reflective exercises capable of acting in the social field, and anthropic interactions. Environmental education as a sequential and continuous process will have direct effects on territorial management models and the risk management of anthropic activities.

It is not possible to disassociate territory management and risk management from potentially or actually polluting activities that shape environmental education. Territorial management involves the management of environmental risk, as well as the management of the resulting planning measures for responses in the event of environmental disasters. Callan and Thomas (2016) place risk management in a dual perspective. The first is risk assessment, which is oriented towards the "qualitative and quantitative evaluation of the risks posed to health or the ecology by an environmental hazard" (Callan; Thomas, 2016, p. 20). Risk assessment seeks to identify causal relationships that pose even a potential threat to humans or the ecosystem. It is influenced by the principles of prevention and precaution and its implementation depends on the development of the matrices already indicated for the realization of environmental education.

Risk management, in turn, is a sequential step in the assessment that has positive results regarding the need to adopt measures in the face of potential threats. Risk management is marked by the adoption of true management of harmful situations caused either by human action or by the contingency of natural disasters. Territory management and administrative conduct itself depend heavily on technical and critical elements, as they are responsible for laying the foundations for technical and resource allocation in order to face not only the risk of disaster, but also the management of the environmental disaster cycle.

The applied linking of the bases of environmental education, considering the critical and reflective process of "bringing to light", is a determining assumption for territorial management and risk management capable of meeting the purposes of prevention and precaution. Environmental education paves the way for formulating criteria and building organizations capable of promoting productive sustainability and risk control. Risk assessment and management also impact sociopolitical and sociocultural options, which determine levels of legal permission

or prohibition. These levels represent the social acceptance of the scale of risk that a society can tolerate and how this level of risk appears acceptable for each territorial zone, including the environmental assets located there. Territory management asserts itself in a non-linear dosage, but rather in arguments marked by a dialectical charge.

Reflecting on the succession of time and space implies an incursion into risk assessment and management of both the dialogical components of popular participation, focused on citizenship, and the effects and impacts on future generations, which denotes the intergenerational nature involved. However, support for this entire chain inevitably depends on compliance with the constructive and reconstructive matrices specific to environmental education. It goes beyond the simple perspective of environmental education as a romanticized discourse to embrace environmental education as an instrument of critical densification in territorial management and in enabling solid pathways in risk management.

The identification and technical diagnosis of the dimension of risks involved not only for the human species, but, rather, considering ecosystems as a whole, demands the articulation of reflective and purposeful rational and dialogical pathways. These pathways provide formulations of understanding regarding possibilities and mechanisms materialized in the management of both the territory specifically considered and the risk posed by the anthropic practices therein. One of these pathways is fuzzy logic, which is expressed as an applied result of risk and territory management perspectives forged from specific angles extracted from the national and international parameters of the regulations governing environmental education.

## 4 Risk management, environmental education, and fuzzy logic

Risks can be voluntary or involuntary, the latter including environmental disasters, whether caused by anthropogenic, natural, or mixed factors. Risk management defines not only the measures to be adopted to avoid the realization of a disaster, but also how to react to it. Therefore, there is relevance in suppressing the logic of yes or no by the logic of potentiality. The logic of potentiality emerges from the scientific parameters of questioning certainty, of constantly disturbing dogmas by expressing their solidity in the face of critical pathways that are opposed to them. Replacing the logic of yes or no, or of perpetuity without criticism, expresses the direct application of environmental education in risk management. Herein lies the foundation of fuzzy logic.

Unlike traditional logic, fuzzy logic works with cloudiness or imprecision not as a flaw or asymmetry in evaluation or identification. Fuzzy logic deals with uncertainty and imprecision as inherent to the critical element of correspondence or succession of reality. With the support of environmental education, the expression of critical sense and the scientific bases of evaluation assimilate uncertainty and imprecision as points not to be defeated, but rather to be addressed in their own irrepressible way in the context of the risk society.

Territorial organization and its environmental impact and risk management are still tied to elements of traditional logic. Precisely for this reason, the dimension of risk and potential disasters reaches levels of response that are often uncoordinated and deficient. Risk management requires an epistemic turn that repels the urge to solve the uncertainty or imprecision of effects through easy answers that avoid complexity through dogma. Fuzzy logic is commonly applied to computer science and has differences from traditional logic that are compared by Gomide, Gudwin and Tanscheit:

> In fuzzy logic, the truth value of a proposition can be a fuzzy subset of any partially ordered set, unlike binary logic systems, where the truth value can only take on two values: true (1) or false (0). In multi-valued logic systems, the truth value of a proposition can be either an element of a finite set, in an interval, or a Boolean algebra. In fuzzy logic, truth values are expressed linguistically, (e.g. true, very true, not true, false, very false, […], where each linguistic term is interpreted as a fuzzy subset of the unit interval.
>
> Other characteristics of fuzzy logic can be summarized as follows: in binary logic systems, the predicates are exact (e.g. even, greater than), whereas in fuzzy logic the predicates are fuzzy (e.g. high, low, …). In classical logic systems, the most commonly used modifier is negation, whereas in fuzzy logic a variety of predicate modifiers are possible (e.g.: very, more or less, …). These modifiers are essential in the generation of linguistic terms (e.g.: very high, more or less close, etc.).
>
> In classical logic systems there are only existential ( ) and universal ( ) quantifiers. Fuzzy logic admits, in addition, a wide variety of quantifiers (e.g.: little, several, usually, often, around five, etc.) (Gomide; Gudwin; Tanscheit, 1995, p. 1; our translation).

Risk management and the critical expression of territorial management in the face of risk activities, with the support of environmental education and its consolidation in human practices, goes beyond the binary response to gain the ability to face cloudiness. Affirmation and denial are put into critical and scientifically formulated expressions for densification. Environmental education applied with the support of fuzzy logic provides theoretical and practical underpinning so that routine answers that say "yes" and "no" at the same time can be surpassed

in both consistency and efficiency. The binary content is overcome to achieve a critical strategy of potentialities and epistemic diagnosis in the face of uncertainty and the multivaluation of effects.

The application of fuzzy theory in the articulation of risk management opens up space for overcoming skepticism or resistance that leads to cleavages anchored in the binary expression of the answer. Argumentative arrangements that express scientificity and supplant dogmas are made possible, presenting environmental education as a way of overcoming dogmatic discourses that claim to solve epistemic problems. Furthermore, instrumentalization is provided so that society, the market, and the State can establish critical argumentative gradations to overcome the "all or nothing" approach. The diagnosis of reality and the coping attitude provided by the materialization of environmental education in risk management experience a higher level of discursive maturity in the diagnosis of reality immersed in cloudiness.

Risk management works with the paradigm of correlation between the potential for occurrence, or probability, and the magnitude of the effects of the occurrence. This means that the low probability of occurrence is not a risk exclusion factor, on the contrary, it is a factor that requires greater attention when the magnitude of possible events generates a terrifying expectation of consequences. A binary logic of risk management is contrary to the applied level of environmental education, especially if taken from the fuzzy logic of realization. If, at some point, the risk does materialize, unless there is effective management, what we have is the potential to prevent it from occurring in certain places or situations, and to adopt a guideline of mitigations to contain its effects.

Here we have a paradox of effectiveness: admitting that the disaster resulting from a risk will occur allows us to prevent the event from occurring. In other words, we are working with the concreteness of the magnitude of the risk and possible damage. This does not mean resignation or diversion of attention to focus only on the consequences of the disastrous event, but rather a driving force to find the balance of strategic actions that take the magnitude of the potential risk seriously in order to adopt preventive and mitigating measures given the level of probabilities. The binary answer, centered on yes or no, is not suitable for this confrontation. The assumption of cloudiness, and the concentration on scientific improvement and denial of discursive ossification are fundamental pillars.

A relational concept, assuming levels of gradation specific to the management situation, allows identifying cyclical scenarios implied in risk management, involving the following steps: disaster risk mitigation; development of planning

and execution of responses in the face of disasters and emergency situations generated; adoption of compensation and stabilization measures and programs; reconstruction of affected areas and lives, followed by new execution panels and mitigation planning, with reopening of the cycle (Carvalho; Damacena, 2013). This confrontation becomes impossible if the logic assumed is binary. In other words, the concrete expression of environmental education in a risk society is not compatible with binary confrontation patterns, which deny cloudiness and uncertainty as components of assessment and management.

The sequential fluctuation of the cycle requires a plastic nature to the legal-normative measures that provide each of the phases with a greater claim to effectiveness, enabling scientific or technical areas to carry out their tasks by means of legal norms. In other words, legal norms are in themselves a shell that allows engineering, health surveillance, medicine, geology, ecology, among others, to act in situations of potential or actual risk of disaster. This interdisciplinarity[11] can only be materialized through fuzzy logic, which is disturbed by binary criteria.

In fact, economic factors are brought to the fore, and not ignored. Environmental education starts from concrete social, economic, legal, and cultural circumstances and then it can take action. Without this, it risks becoming hermetic in itself, becoming a metaphysics of environmental education. Therefore, factors of stratification and distributive factors of income and risk are important when considering management variables and the concrete application of environmental education. After all, they cause disparities in exposure to the effects of materialized realized, as highlighted by Daniel Faber, when considering the need for studies and assessments of the implications between disasters and maladjustments in social organization. The author explains that:

> […] current research on the subject is sparse, but what we know at this point is enough to indicate clearly that race and poverty, along with age and gender, make a significant difference. Those who already suffer from social disadvantage are more likely to be in harm's way, and they are less likely to be able to take defensive action or to reconstruct their lives after a disaster (Faber, 2007, p. 302).

Clearly, the characteristics of disaster management demand different plans

11 The importance of inter- and transdisciplinarity with regard to environmental legal issues is highlighted by Reis, Kokke and Couto (2022, p. 163; our translation): "Interdisciplinarity and transdisciplinarity are fundamental to several contemporary issues, including as regards Environmental Law. Many areas are related to Environmental Law. Architects and urban planners, landscapers, engineers from the most diverse specializations, social scientists, sociologists, philosophers, biologists, veterinarians, politicians and economists, for example, are some of the professionals who at some point think about topics included in Environmental Law and which can contribute to its rationale".

for response, open to cloudiness and uncertainty, in a range of reactive expressions that do not shut themselves off from managing the unexpected, on the contrary, they assume it as inherent to the risk society. For example, an Environmental Disaster Recovery Plan (DRP) is a response planning linked to the organization and management of the territory, as it comprises local, regional, and even national levels of reestablishment. Its formulation corresponds to fuzzy logic, and its solid foundation lies in environmental education. The plan ranges from responding to rescue and salvage situations to establishing waste management and recovery of degraded areas, in a sequential and evaluation process that can last decades. Diagnosis and reactive measures are materialized at levels of interdisciplinary diagnosis, and not in dogmatic closures that aspire to certainty.

The risk-related assessment parameter must take into account the so-called worst-case scenario, i.e. the likelihood of the worst possible scenario occurring in the event of the risk materializing, alongside a rigid assessment of the strength of the mechanisms planned and ready for execution in each of the phases of the cycle, the hard look doctrine. Regarding worst-case scenarios, Cass Sunstein (2009) lists factors that seek to explain the collective disbelief in relation to the potential for disaster, damage, and destruction to affect human life that do not correspond to the levels of concern and precaution that were (or should be) adopted to avoid tragic consequences. There is a direct correlation here with the challenges facing environmental education. It is about adopting measures to mitigate and even overcome the occurrence or effects of a disaster in the face of the worst-case scenario, as a true precautionary measure[12].

The factors argued by Sunstein are linked to an unrealistic, artificial optimism in the face of risk, with a belief in immunity in relation to the consequences or the magnitude of the effects, or, alternatively, in an attempt to non-traumatically overcome the event, which can be summarized in the popular phrase "everything will be fine". A second factor is unrealized risk. In similar cases, in which a series of thresholds were adopted to avoid causing catastrophic damage, with economic costs and expenditure of time and energy, without anything occurring, an erroneous perception of unnecessary expenditure may arise.

Here, there is a potential feeling of futility of the measures taken then,

12 In the author's words: "If we focus on the risk of catastrophe, a distinctive version of the Precautionary Principle is possible: When risks have catastrophic worst-case scenarios, it makes sense to take special measures to eliminate those risks, even when existing information does not enable regulators to make a reliable judgment about the probability that the worst-case scenarios will occur. I shall call this the Catastrophic Harm Precautionary Principle" (Sunstein, 2009, p. 119).

intuiting that nothing will happen in other situations, presupposing an uncertain continuity of the non-occurrence of the damage. Finally, there is a component linked to the infiltration of emotional elements that remove the rational calculation that aligns vulnerability and magnitude from risk assessment. Emotional elements affect judgment. Because the catastrophe is linked to feelings that generate repudiation or suffering, there is a prior tendency, an antagonized pre-disposition regarding the harmful effects that may occur, in a true denial of socially shared possibility. The implementation of environmental education and the expression of risk management through fuzzy logic are suitable ways to confront these factors of dogmatic repulsion towards denial. Interdisciplinary work is carried out so that uncertainty and the expression of damage are not trivialized in everyday life.

According to Sunstein (2002, p. 105), "the probability of harm is often neglected when people's emotions are activated, especially if people are thinking about the worst-case scenario". Because of these factors, "people try to avoid cognitive dissonance, sometimes by thinking that they are 'safe' and by treating a low-level risk as if it were zero" (Sunstein, 2002, p. 106). At this point the hard look doctrine comes into play. Here, State bodies and all those involved in risk management are required to adopt a rigorous regulatory application that effectively protects the legal interests involved[13].

The social characteristics of repulsion regarding risks, highlighted by Sunstein, are inherent to territorial management. The challenge of environmental education is therefore one of intuitive reversal, of cultural reversal of the denial that ignores risk management. Verónica Viñas, when dealing with the Prestige case, points out that disasters cause mobilizations that are linked to a framework for understanding public policies, because "*En el análisis de políticas públicas no sólo se considera relevante qué problemas han sido incluidos en la agenda pública o en la agenda gubernamental, sino también cómo se ha definido ese problema*"[14] (Viñas, 2009, p. 124).

The correlation of the application of environmental education is unquestionable. Environmental disasters are generally accompanied by concrete response measures, related to the case itself, and with new normative measures for

13 The institute is linked to due legal process and mechanisms to safeguard normative effectiveness: "hard look can thus be seen as inherent in the very process of judicial review. In a way, hard loo represents an internal duty owed by the courts to the constitutional function of judicial review, rather than an external duty of the type imposed by the APA on the relationship between the courts and administrative agencies" (Garry, 2006, p 170).

14 Our translation: "in the analysis of public policies, it is only considered relevant that problems have been included in the public agenda or on the governmental agenda, it is also how this problem has been defined"

risk assessment and prevention regarding their occurrence, which establishes a new level of security requirements subject to gradations that assimilate uncertainty, which demands the application of fuzzy logic so that risk management can be effectively operationalized.

In a comprehensive study carried out by Robert Emmet Hernan (2010), in which fifteen of the world's worst human-caused disasters were selected, the author sees a point in common: these disasters are characterized by a unique opulence of the enterprise or agent responsible, raising questions about the levels of fragility on a local or even regional scale for overcoming economic pressure. This means that the technical and management approach is subject to weaknesses, preventing the consideration of risk variables in their cloudiness range (fuzzy logic) and the imposition of practices for reversal of vulnerability to the materialization of disaster. There is no densification and implementation of environmental education as a guiding vector for management, whether public or private.

## Conclusion

The historical and conjunctural understanding of environmental education based on the shaping and germinating matrices of education in the West is the foundation for its effective consolidation and continuous applied reconstruction. Understanding education as a historical path that connects awareness, knowledge, attitude, skills, and the ability to evaluate measures to be taken in the face of problems experienced, in a context of dialogical participation, provides the densification of the foundations for diagnosing, tackling, and responding to environmental problems that are unique to the risk society.

It is in this scenario that environmental education is situated, in its capacity as an instrument for promoting and implementing the rules and principles of Environmental Law. Both in national and international normative frameworks, environmental education goes beyond abstract perspectives and is connected to the establishment of public and private management bases. Environmental education is understood both as a continuous process of raising awareness and as a process of individual and social empowerment. The internalization and institutionalization of environmental education at different social, economic, cultural, and legal scales produces direct effects on risk management.

Risk management in its application therefore depends on the institutional densification of environmental education in its varied manifestations of interdisciplinary coalition. On an applied scale, environmental education,

densified and applied to risk management based on fuzzy logic, allows us to overcome problems inherent to the risk society. The binary system for dealing with situations that are potentially or actually polluting, as well as the binary system for dealing with situations of magnitude and probability of damage considered as environmental disasters, is not suitable for overcoming the conjunctural problems that permeate society and are interconnected with anthropic activities.

The construction and application of risk management models that assimilate the densification of environmental education and are parameterized by fuzzy logic in the diagnosis of reality, and subsequently in the assessment of negative potentialities and mitigation, control, and response planning, is an unavoidable step in contemporary environmental management, both public and private. The uncertainty, imprecision, and variation inherent to a margin of cloudiness that cannot be dispelled must be assimilated by the model in its articulated and interdisciplinary management. This allows for a multivaluation of possibilities and risk components, to be articulated as an object for reflection and clarification in the coping matrix of environmental education.

Economic, social, cultural, and legal complexities, as well as locutionary and illocutionary factors are drawn in and problematized discursively. Environmental risk management moves away from abstraction, takes on its challenges and limits, and ties itself to the foundations of epistemic criticism and evaluation. The path of environmental education revolves simultaneously in epistemic solidity and pragmatic commitment, bringing together aspects of risk management in view of its constant need for improvement in the face of the complexities inherent to the impacts of production models and the social and cultural reactivity in which the actions of market players and state regulatory bodies take place.

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