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Connections between science fiction, scientific literacy and socio-environmental issues: reflections for science education

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ABSTRACT

This work explores the intersection between Science Fiction (SF), Scientifc Literacy (SL), and Socio-environmental Issues, investigating their possibilities and potentialities in a critical and transformative Science Education. Using a qualitative, theoretical, descriptive, and exploratory approach, the study analyzes elements found in SF works, especially within the subgenre of climate fiction (cli-fi), that can be used to promote and stimulate discussions about socio-environmental issues and develop the premises of SL. Initially, analyses of works by other studies are discussed, followed by the investigation and analysis of the TV series Extrapolations (2023), using principles of film analysis. From the analyses, we highlight the presence of various significant aspects for the socio-environmental approach within the genre, such as: scientific concepts, the impacts of environmental degradation on humanity, environmental injustice, inequalities, the need to break oppressive structures, among others. It is concluded that the use of SF works can stimulate critical reflections on the role of science in social transformation and the search for a more sustainable and ethical future, aligning with the premises of SL.
KEYWORDS: science fiction; scientific literacy; socio-environmental issues; film analysis; TV series in science education.

Conexões entre ficção científica, alfabetização científica e questões socioambientais: reflexões para o ensino de ciências

RESUMO

Este trabalho explora a intersecção entre a Ficção Científica (FC), a Alfabetização Científica (SL) e as Questões Socioambientais, investigando suas possibilidades e potencialidades para um Ensino de Ciências crítico e transformador. Partindo de uma abordagem qualitativa, teórica, descritiva e exploratória, o estudo analisa os elementos presentes em obras de FC, especialmente do subgênero *climate fiction* (*cli-fi*), que podem ser utilizados para promover e estimular discussões sobre questões socioambientais e desenvolver as premissas da SL. Inicialmente, são discutidas análises de obras realizadas por outros estudos. Em seguida, utilizando pressupostos da análise fílmica, procede-se à investigação e análise da série televisiva *Extrapolations: Um Futuro Inquietante* (2023). A partir das análises, evidenciamos a presença de diversos aspectos significativos para a abordagem socioambiental considerando o gênero em questão, tais como: conceitos científicos, impactos das degradações ambientais para a humanidade, injustiça ambiental, desigualdades, a necessidade do rompimento das estruturas de opressão, entre outros. Conclui-se que o uso de obras de FC pode estimular reflexões críticas sobre o papel das ciências na transformação social e na busca por um futuro mais sustentável e ético, alinhando-se às premissas da SL.
PALAVRAS-CHAVE: ficção científica; alfabetização científica; questões socioambientais; análise fílmica; séries no ensino de ciências.

INTRODUCTION

Questions and concerns surrounding socio-environmental issues have taken on an increasingly relevant role in contemporary discussions, especially in the light of environmental challenges we face. These issues are important in the context of Science Education, allowing, among other factors, an interdisciplinary teaching that integrates several areas of knowledge and enables a broad, critical understanding of reality.

The work with socio-environmental issues in science education, from contextualized and problematizing approaches, allows the development of strategies that assist in the understanding, analysis, judgment and decision-making regarding problems faced by the community and the world, enabling the formation of citizens who are active and critical in society (Santana & Santos, 2009; Ferreira, 2011).

In fact, due to the importance of environmental issues, sustainability is one of the main drivers of the science education curriculum based on Scientific Literacy that aims at the emancipation and scientific engagement of students (Sjöström & Eilks, 2018).

In view of this environmental scenario, it is necessary to think about Scientific Literacy based on a formative process that seeks to enable students to expand their knowledge through contact with elements of scientific culture, which can be useful in the evaluation and making of conscious decisions in everyday life (Gil & Vilches, 2001; Souza & Pinheiro, 2018; Valladares, 2021). In this way, students are allowed to effectively participate critically in their realities, especially regarding current environmental issues.

It is important to consider cultural products in our reflections, since they can present elements that manifest certain ideals, conveying specific types of ideologies and cultures. In this way, they can shape political opinions and social behaviors by transmitting ways of acting, what to think, what to feel, what to believe, what to fear, what is moral or immoral, what is good or bad – in other words, specific values (Kellner, 2001).

Kellner (2001) also points out that such products provide materials that can constitute the identity of people, who use them to construct their sense of class, ethnicity and race, nationality, and sexuality. Thus, media culture shows to be a terrain of dispute, in which the fundamental conflicts of society are reproduced at cultural level. Films are considered as one of the main productions of media culture, and in line with this, Turner (1997, p. 13) points out that “cinema is a social practice for those who make it and for the audience. We can identify evidence of the way in which our culture gives meaning to itself in its narratives and meanings” (our translation).

We understand that such reflections about media in the context of socio-environmental issues are important because there are several productions, such as films and series, which carry and convey environmental issues in a variety of ways. Therefore, they can be excellent materials and resources for a Science Education that is concerned with approaching these issues critically.

In this context, this work, which is theoretical, descriptive and exploratory in nature, aims to identify and analyze elements of Science Fiction works (especially

those characterized in the climate fiction subgenre) which can be used to promote and stimulate the approach and discussion of socio-environmental issues in Science Education, establishing relationships with the premises of Scientific Literacy. In this way, we aim to contribute to a critical and emancipatory teaching, committed to the need for social transformation.

In order to support the discussions and relationships previously proposed, we begin by outlining the methodological set adopted. Then, we present reflections on the characteristics of Scientific Literacy and the Science Fiction genre. Subsequently, based on analyses of works carried out by other researchers, we explore some of the relationships between the themes under study. Next, we investigate the television series *Extrapolations* (2023) to provide examples and discussions that describe and explore these relationships, highlighting their relevance for the construction of critical and transformative Science Education.

METHODOLOGICAL SET: GUIDELINES FOR RESEARCH

With the view to achieve the proposed objectives, we applied a qualitative approach (Stake, 2011) to our work, seeking the meanings produced in the various contexts of message production (Minayo, 2012). To this end, we mainly used the methodological triangulation (Flick, 2009) and film analysis.

For establishing our first relationships between cli-fi Science Fiction works and Scientific Literacy, we start with a reflection based on film analyses carried out by other studies. Then, we developed our own analysis for a work of the genre.

To continue with this analysis, we will consider mainly the assumptions and elements of Vanoye and Goliot-Lété (2012) film analysis. Although the authors work specifically with films, we understand that these assumptions can also be applicable to series. This is because, despite some distinct characteristics in the production format of these works, both share similar audiovisual languages as means of expression.

Vanoye and Goliot-Lété (2012) highlight two essential stages for film analysis: (1) deconstruction, which ensures distance between the work and the analyst, allowing its decomposition into fragments and constituent elements, facilitating its description; and (2) reconstruction, which establishes connections and links between the fragments, enabling the interpretation of the work.

To proceed with the analysis and interpretation, the authors use a useful strategy for the deconstruction and description of the work, which we will also use in our study. The strategy consists of describing/transcribing scenes from the work based on a three-column table: (i) shot used, (ii) what is seen and (iii) what is heard.

To define nomenclatures, we understand the “scene” as a set of shots that take place in the same place and at the same time (Gerbase, 2012). The term “shot” refers to everything that is shown to the viewer through a succession of moving images without any type of interruption. It is a portion of the work recorded between two cuts (instantaneous transition between two shots), and is characterized by some elements such as: duration, filming angle and type of framing (Bernardet, 1980; Gerbase, 2012; Vanoye & Goliot-Lété, 2012).

The distinct types of shots contribute to the perception of the content, which may vary depending on the chosen shot (Sousa, 2012). In the literature of the area, there are several classifications and nomenclatures for the different types of shots, which basically consist of the distance between the camera and the filmed object. For our study, we adopted the language proposed by Gerbase (2012), as shown in the table below.

Table 1

Classification and description of distinct types of shots.

Shot	Description
Extreme Wide Shot (EWS)	The camera reveals a large scene, and the human figure occupies a reduced space on the screen.
Long Shot (LS)	The character takes up more screen space, with some recognizable faces, but a sizable portion of the scenery is still visible.
Full Shot (FS)	The human figure is entirety framed, between two bands (one of "air" above the head, and one of "ground" under the feet).
Cowboy Shot (CS)	The character is shown from the knee up.
Medium Shot (MS)	The character is framed from the waist up.
Medium Close-up Shot (MCUS)	The character is framed from the chest up.
Close-up Shot (CUS)	The human figure is presented from the shoulders up.
Extreme Close-up Shot (ECUS)	Framing an object or a part of the face or body (an eye, a hand, a foot, etc.).

Source: Prepared by the authors, based on Gerbase (2012).

SOME NOTES ABOUT SCIENTIFIC LITERACY AND SCIENCE FICTION IN SCIENCE EDUCATION

Scientific Literacy (SL) has been discussed and worked on for a long time by several authors. Due to the numerous studies, it has been presented as a concept of multivariate nature. For now, we understand SL as a formative process in which the language of science assumes meanings that allow the subject, inserted in each context and society, to expand their knowledge and culture through contact with elements of scientific culture. These can be useful in the evaluation and decision-making in their daily lives, in addition to facilitate the reading of the world in which they live, helping in the understanding and the need to transform it for the better. (Lorenzetti & Delizoicov, 2001; Chassot, 2016; Silva & Sasseron, 2021).

For Chassot (2003, p. 99), Scientific Literacy aims

> Contribute to the understanding of knowledge, procedures and values that allow students to make decisions and realize both the many uses of science and its applications in improving quality of life, as well as the limitations and negative consequences of its development (Chassot, 2003, p. 99, our translation).

According to Chassot himself (2016, p. 70), “it is necessary to show that it *[science]* is not only a benevolent fairy, but also a destructive witch” (our translation). Based on these assumptions, we also consider discussions about the process of scientific practice and the implications of its undertakings (Sasseron, 2008).

Souza and Pinheiro (2018) point out that, with the development of SL, it is possible to educate citizens who are able to understand and intervene consciously, critically and responsibly in the world, thus contributing to the development of a society capable of acting reflectively in the face of situations and events that arise and affect their environment, such as socio-environmental issues. In a complementary way, Bicalho, Farias and Arrais (2024, p. 181) argue that this scientific education made possible by SL is "a key element for the promotion of active and conscious citizenship in relation to contemporary challenges" (our translation), such as environmental issues.

When developing projects/classes focused on SL, it is important to establish activities and discussions with students about the process of scientific work and the implications of their endeavors (Sasseron, 2008), providing the development of "investigative skills, such as hypotheses formulation and testing, critical data analysis, and creation of solutions based on scientific knowledge" (our translation). Thus, "tools that allow citizens to interpret the world in a critical, responsible manner can emerge. This enables individuals to make informed decisions, whether in everyday issues or in broader debates about environmental public policies" (Bicalho, Farias & Arrais, 2024, p. 186, our translation).

Bicalho, Farias and Arrais (2024) discuss SL together with environmental literacy and conclude that they should promote the understanding of global problems, such as pollution, deforestation, and climate change, helping to improve the quality of life through a healthier and more balanced environment, since

> (...) scientifically and environmentally literate citizens can proactively engage in debates on environmental public policies, propose evidence-based solutions and sustainable practices, in addition to mobilize their communities for environmental preservation and recovery. These individuals can understand contemporary environmental crises and propose solutions that not only mitigate damage but also transform habits for a sustainable future. (Bicalho, Farias & Arrais, 2024, p. 189, our translation).

These conceptions of science education, engaged with environmental issues and concerned with the critical and transformative dimension of Science Education, are close to Vision III of SL. Vision III, together with Visions I and II, is the result of efforts by recent studies that sought to systematize, in analytical categories, the various conceptions already created and worked on regarding SL. It is not within the scope of this work to detail the three Visions in an exhaustive manner. However, we believe it is important to reserve a space to discuss them, even if briefly, because they help us to understand what SL is and what its main premises and objectives are.

In a systematic way, "Vison I focuses on disciplinary scientific content knowledge, Vision II on usefulness of scientific knowledge in everyday life, and Vision III on critical praxis in relation to science and technology in society" (Sjöström & Eilks, 2018, p. 77).

Thus, Vision I focuses on the conceptual dimensions of science and the learning of scientific content and processes. Vision II emphasizes the usefulness of scientific knowledge for society, relating it to cultural (values, beliefs, emotions), historical, philosophical, and sociocultural contexts and dimensions. Vision III seeks to delve deeper into the ethical, social, and transformative aspects of science (Valladares, 2021).

We emphasize that, despite their specificities, these Visions enhance each other, constituting a *continuum* (Liu, 2013; Valladares, 2021). Thus, it would be undesirable to focus on just one of the visions (Liu, 2013) since they all have important characteristics for Science Education.

In her study, Valladares (2021) points to the existence of a world characterized by the anagram VUCA (volatility, uncertainty, complexity, and ambiguity), which characterizes the current social, ecological, political and economic systems. The author points out that a flexible SL, committed to social transformation and that seeks to break with different structures of oppression, promoting greater social activism and critical thinking, is a way to face the complex challenges of the 21st century, such as the search to prevent a further worsening of the environmental crisis.

Thus, science education could seek to promote a "more equitable distribution of the benefits of science to build more global resilience, projecting new anti-oppressive and more supportive and sustainable social relationships, not only among human beings, but also between them and the environment" (Valladares, 2021, p. 565).

Given these assumptions and objectives of SL, some questions may arise: How to develop Scientific Literacy? Which materials and resources make this work possible? What strategies provide opportunities and enhance the development of such SL premises?

We have been working with the perspective that the premises and objectives of Scientific Literacy can be developed and provided through the use of Science Fiction (SF) works in Science Teaching (Menezes & Sessa, 2024a; Menezes & Sessa, 2024b). The use of this genre has been discussed and suggested in some research developed within the scope of scientific education, which emphasize that its use enhances the production of meanings for scientific knowledge; broadens the cultural formation of students (Ferreira & Barbosa, 2018), favors the awakening of imagination and understanding of scientific concepts (Martins, 2018; Ribeiro, 2018), allows the development of interdisciplinary projects and activities (Santos & Silva, 2017) and enables discussion on social, historical and political aspects linked to the process of scientific practice (Piassi, 2013).

We add to this the discussions brought by Zanetic (2005), who points out that scientific education should not give up, among other elements, of the existing connections between science, society and other areas of culture – although the author discusses, specifically, physics teaching, we understand that his argument encompasses Science Education as a whole. Thus, the aim is to favor the construction of a problematizing, critical, active education engaged in the fight for social transformation. The author adds:

> A determining factor in guiding a young person towards the enchantment of knowledge, towards the establishment of an intelligent dialogue with the world, towards the conscious problematization of themes and knowledge, is the experience of a rich, stimulating school and cultural environment, which allows the blossoming of epistemological curiosity. (Zanetic, 2005, p. 21, our translation).

These other areas of culture, which must be considered in Science Education, can be represented, for example, by audiovisual media, which, in our case, appears with Science Fiction films and series.

Science Fiction (SF) is a form of cultural discourse present in various contexts – literature, cinema, television, games – that creates, extrapolates and explores alternative universes related to scientific and technological themes (Roberts, 2018). Although scientific discourse is present in works of this genre, in most cases, we have the extrapolation of science as one of its main characteristics. In other words, SF presents convincing, but not always real discourses (Carneiro, 1968; Allen 1974). This is an important aspect to highlight since, according to Tavares (1986, p. 10), we must "recognize that within the genre certain freedoms are allowed, and even more: that without them the genre cannot work" (our translation). A caveat is in order here: we must consider these possible conceptual errors when using a SF work in Science Education, however, they cannot be an obstacle. Using works of this genre just to find conceptual errors would be a waste of material, as there are other riches that they can provide us, as we will discuss later.

In line with this, we add the discussions of Junqueira (2021), who indicates that we should not demand that SF provide plausible, safe, valid and scientifically verifiable answers to humanity's questions, since such demands are not part of its objectives and are not included in its spheres of purposes and competences. However, SF has an important social value, as it is "capable of generating symbolic keys for the interpretation of the present reality, carrying contributions to reflections on the future of humanity, as well as on the roles and meanings of science and technology" (Junqueira, 2021, p. 92, our translation).

There are several elements in SF that allow us to situate the work in an imaginative framework that is alternative to the real world, that is, that allow us to verify that these are alternative universes, for example, through the presence of “enginery” produced from extrapolated sciences and technologies, such as time machines, spaceships, future environments, among others (Allen, 1974; Roberts, 2018).

These changes and extrapolations are usually inserted in certain contexts, highlighting interests and concerns related to their sociocultural impacts and possible consequences for people's lives (Allen, 1974; Piassi, Gomes & Ramos, 2017). Thus, Piassi (2013) emphasizes that, far from being works that are only concerned with empty speculations about the future, SF conveys concerns of the present in which it was produced, reflecting worries of its period of production, mainly those related to scientific and technological issues in society.

We can mention that one of these concerns refers to the "anxieties" and "fears" in relation to science and its implications. In SF, every scientist is subject to being portrayed as a hero (anxieties) or a villain (fears) (Tavares, 1986). The various plots constructed in SF can allow such reflections on the ethical and social use of science.

One of the SF subgenres, and which we are particularly interested in our current study, is the so-called climate fiction or cli-fi, due to a mixture of sci-fi and climate change fiction (Penteado, 2022). Here it is worth noting that there is no consensus on whether "climate fiction" is a new genre, whether it is a topic found in several other genres, or whether it is a subgenre of Science Fiction. In our study, we will use works that, more generally, are classified as SF genre, but with cli-fi characteristics and elements. Thus, in part we will consider and adopt cli-fi as a SF

subgenre. In any case, these works address climate change and its physical and social impacts (Emerick, 2022).

Emerick (2022) shows that cli-fi works address climate-related issues both as a way of alerting the human species on the possible risks of environmental disasters and as a way of addressing some social issues related to development combined with devastation. Themes such as environmental injustice and the impacts of these contexts on the most vulnerable populations are also often present in the works.

Finally, Junqueira (2021) presents us with some other characteristics of cli-fi works and some of the themes and values they address:

> Most initiatives in this sense involve frightening narratives, both more sinister and more plausible about the dystopian and post-apocalyptic future of humanity and, possibly, of all nature and the Earth. These are stories built on the risks of the dominance of totalitarian powers, of induced biological mutations and transgenics, of predatory practices in industry and markets, and of the irrationalities, vanities, frivolities and inconsequence of human behavior (Junqueira, 2021, p. 92, our translation).

Once some of the main characteristics of Scientific Literacy, Science Fiction and cli-fi works have been established, the following topics explore the relationships and similarities between them, highlighting their contributions to Science Education.

APPROACHES AND RELATIONSHIPS BETWEEN SCIENCE FICTION, SCIENTIFIC LITERACY AND SOCIO-ENVIRONMENTAL ISSUES

In her study, Penteado (2022, p. 2) argues that cli-fi works are presented as "a fertile field for thinking about women's participation in the fight for environmental preservation and for a more just and egalitarian society, (...) highlighting the need to think of alternatives to replace the current system" (our translation). Because of this, such works can be promising when used as materials in teaching processes that take into account the premises of Vision III of SL, since this Vision is concerned, among other factors, with the search for resolutions to social and scientific problems in a fair, equitable way, committing to ethics and local and global good, and with breaking structures of oppression (here exemplified by the role of women in society) (Valladares, 2021). Thus, these works have the capacity to enable classroom activities that allow discussions about such objectives.

From here, we begin and propose, in a more categorical way, some approaches between Science Fiction, Scientific Literacy and Socio-environmental Issues. Preliminarily, we present the following table, which summarizes some information about the main works discussed in this topic. Then, we explore these works in more details.

Table 2

Main cli-fi works covered in this topic and present in the literature, organized in chronological order of release.

Work (Authors who analyzed the movie)	**Work analyzed** (Movie used)	**Visions of SL emphasized**	**Examples of themes addressed in the movie**
Emerick (2022); Emerick and Cunha (2023); Queiroz and Rocha (2021)	*The Day After Tomorrow* (2004)	Visions I, II and III	- Global warming. - Climate change. - Relationships between science and politics. - Conceptual aspects of science. - Public participation in science. - Representations of "scientists".
Penteado (2022)	*Pumzi* (2009)	Visions II and III	- Environmental and economic destruction. - Unequal social impacts of natural disasters. - Environmental injustices. - Role of women in society. - Relationships between science, technology and sustainability.
Junqueira (2021)	*Downsizing* (2017)	Visions II and III	- Technological inventions and science methodologies. - Technological solutions to environmental and social problems. - Unbridled consumerism. - Ethical debates and market interests. - Access to the benefits of science.

Source: Prepared by the authors (2025).

Penteado (2022) points to a recent, popular work that addresses issues surrounding the environmental crisis: *Mad Max: Fury Road* (2015). However, the researcher has a particular interest in cli-fi works produced by women, and, among several examples mentioned, both in literature – when quoting female authors such as Ursula Le Guin, Octavia Butler and Margaret Atwood – and in cinema, we highlight here a cinematographic work cited in her study, namely: the movie Pumzi (2009), by the Kenyan Wanuri Kahiu.

The movie *Pumzi* (2009) described a future scenario, set years after a World War over water that devastated the world. Penteado (2022) reports that the work presents both environmental destruction and economic destruction, portraying women as the most affected by wars in a community in Africa. A critical position is presented regarding current and potential future environmental catastrophes.

In addition, due to its origin, the work also allows for reflection on important and complex socio-environmental issues, such as the unequal impacts of natural disasters on different regions and populations, since "these are places *[emerging countries]* that usually suffer the first impacts of environmental crises" (Penteado, 2022, p. 2-3, our translation). These reflections are close to the premises of Vision III of SL, which prioritize a perspective of science focused on a more equitable distribution of its benefits, projecting anti-oppressive, supportive, and sustainable social relationships (Valladares, 2021). This allows the students to reflect on environmental inequalities and injustices based on a work that is not part of the list of so-called "popular" works, thus expanding their cultural repertoire.

Emerick (2022), to exemplify the genre, cites some works that address environmental themes. In addition to *Mad Max*, *The Colony* (2013), *Snowpiercer* (2013) and *Ice Twisters* (2009) are also mentioned. Besides these works, *The Day After Tomorrow* (2004) is perhaps one of the most striking and well-known movies with this theme, whether due to the various studies carried out on it, its impact on public opinion, its high grossing, its use as a dissemination resource by people linked to environmental causes or for having brought the debate on climate change into the public domain (Emerick, 2022; Emerick & Cunha, 2023).

Based on the analysis carried out by Queiroz and Rocha (2021) about *The Day After Tomorrow* (2004), we realize that the work portrays the natural disasters caused by global warming, emphasizing the possible consequences of these changes for humanity. As noted by Emerick and Cunha (2023), throughout the plot, a climatologist tries to alert the authorities about the climate changes he has detected in order to avoid major catastrophes. However, he does not get the due attention. The movie, therefore, portrays some relationships between scientists, science and political actions.

Despite the visual productions considered exaggerated by some critics, the central message about environmental issues is maintained in the work, allowing the approach of several important elements for SL. Conceptual issues of science, such as the Atlantic Meridional Overturning Circulation (AMOC) air current, are present in the plot, allowing an approximation with Vision I of SL, focused on the approach of scientific concepts and phenomena. Premises of Visions II and III can also be addressed with the movie, since it contemplates problems involving science, the environment and their possible social implications, in addition to allow the discussion of controversial, relevant and authentic social and scientific issues, such as sustainability and climate change.

By demonstrating some relationships between scientists and political authorities, including the climatologist speaking at an event promoted by the UN (Queiroz & Rocha, 2021; Emerick & Cunha, 2023), the work also allows a discussion about social and political influences on science, consequently approaching ethical issues, critical social activism and the importance of participation and critical involvement of the population in public/political issues and decisions about scientific themes, as is the case with socio-environmental issues. All of these are premises markedly present in Vision III of SL, which is concerned with social transformation based on Science Education.

When specifically analyzing the figure of the scientist/climatologist (Dr. Jack Hall) in the movie, Queiroz and Rocha (2021) classify him in the category of

"idealistic scientist", as he portrays an image of a scientist concerned with humanity, with a great interest in the community and who believes he can change the world alone. The image of an "idealistic scientist" can convey the notion that science is neutral and always beneficial (the only salvation for humanity). This type of representation can be used as a basis for the teacher, together with the students, to establish discussions capable of deconstructing certain stereotypes in science, especially those previously reported. This is in line with the discussions of Chassot (2016), who points out the need to show that science will not always be the "benevolent fairy", but depending on the context and ethical relationships, it can also be the "destructive witch".

In addition to these aspects, the image of an "idealistic scientist" may convey the idea that complex socio-environmental changes can be achieved only through simple individual changes, disregarding broader relationships and frameworks, such as the capitalist system in which we live, lifestyles based on consumerism, and the need for public policies that aim to reduce environmental injustices. In other words, factors that do not depend solely on individual attitudes. These are also important aspects to consider when addressing environmental issues and that can be raised by the figure of the scientist in the movie.

Junqueira (2021), in turn, analyzes a movie that, unlike the frightening narratives of the vast majority of cli-fi works, has a plot that assumes the light character of comedy and parodic irony. The movie in question is *Downsizing*, from 2017. The movie shows a scenario where, thanks to a scientific-technological invention, some people are subjected to a process of drastic size reduction (miniaturization to a 1/12 scale), starting to live in "microcolonies", where all the objects and consumable goods of the "real" world are also shrunk. In the narrative period, these practices are already dispersed in several microcolonies spread throughout the world and their adoption is encouraged by marketing initiatives.

The discourse that supports the great adherence to miniaturization is the desire to reduce the material and financial volume, which would lead to lower levels of impact and damage to the environment. However, Junqueira (2021, p. 91) analyzes that there is a main underlying reason: "the finding of a way so that different profiles of individuals and families can have access to or continue consuming all kinds of goods without worrying about the evils of slave labor (...)" (our translation). Thus, there is no real reorientation of ideologies and social practices related to consumption, exploitation and environmental damage, but only a simple reduction in the scale of raw materials and products. Therefore, it is clear that, in essence, there is no real concern for environmental impacts, but rather the search for a method of maintaining the *status quo* that enables even greater consumption.

Based on Junqueira's analyses (2021), we observe that, in the development of the narrative, humorous and parodic elements serve as several possibilities for SL. Among these possibilities, we highlight: (i) conceptual approaches, which explore ideas of scale and miniaturization; (ii) methodological and nature perspectives of science, based on the methods developed by scientists for shrinking; (iii) reflections on the relationship between science and society, by illustrating how capitalism can appropriate science and technology; (iv) ethical debates and debates on equal access to the benefits of science, by enabling questions such as: if miniaturization was the appropriate adopted solution, which segments of the

population would have access to it and which would be marginalized/excluded?; and (v) the need for transformation of the world and conscious interventions, since, even in the face of awareness about environmental impacts, there is still human resistance "to changes in their consolidated and overstimulated consumption practices in the context of contemporary neoliberal capitalism" (Junqueira, 2021, p. 91, our translation).

Furthermore, the work also presents some other issues related to the human condition that can be worked with – and together with – disciplines such as Philosophy, Sociology and Geography, highlighting the possibility of interdisciplinary projects with SF works, as pointed out by Santos and Silva (2017).

From the examples and analyses presented in this topic, we realize that Science Fiction cli-fi works present pertinent and relevant socio-environmental elements for science classes from the Scientific Literacy perspective. In order to expand on these observations, in the following topic, we propose to carry out a film analysis of one work of this genre, listing other details of these approaches.

"EXTRAPOLATIONS": ANALYSIS OF THE SERIES AND POSSIBILITIES FOR SCIENCE EDUCATION

Hereafter, we propose to investigate a Science Fiction cli-fi work. We seek to establish, identify and analyze socio-environmental and scientific issues in general addressed by it that may provide opportunities and stimulate the development of the Scientific Literacy premises. The selected work was the series *Extrapolations*, released in 2023 and created by Scott Z. Burns for the Apple TV+ streaming service.

The series describes a near future, when climate change significantly impacts humanity. It addresses topics such as technological advances, environmental and social crises, ways in which society reacts (or would react) to these transformations, consequences of environmental impacts on our way of life, relationships between the private sector and environmental issues, etc. These themes are developed in eight episodes, which follow different stories set over 33 years (between 2037 and 2070).

Initially, we present the following table, which summarizes some excerpts and themes from the series that may relate to SL visions, making them useful for Science Education. These examples will be detailed below.

Table 3

Summary of excerpts and themes examples present in the series and their relationships with the Visions of SL.

Excerpts and Themes in the series	Possibilities and Connections with Science Education	Visions of SL emphasized
Episode 1: Dialogue with 79N ice sheet quote	- Exploration of concepts: functioning of ice sheets and glacial melting. - Approach to methodological aspects: satellite images and detection of melting and the planet's temperature. - Social impacts due to rising sea levels.	Visions I and II
Episode 1: Dialogues and scenes that emphasizing environmental negligence and monetary interests	- Discussion on the impacts of human action on the environment. - Relationships between science, economics, and public policies. - Environmental injustice.	Visions II and III
Episode 3: Scenes and dialogues in a flooded Miami	- Social impacts of climate change. - Water drainage technologies. - Air humidity. - Social neglect and the ethical, social, and transformative aspects of science.	Visions II and III
Episode 4: Geoengineering and climate change	- Scientific concepts and phenomena: chemical reactions, atmosphere, volcanic eruptions, pollutants, etc. - Environmental public policies and relationships between science and politics. - Ethics in science and sustainable practices. - Methodological aspects of science.	Visions I, II and III

Source: Prepared by the authors (2025).

At a given point in the first episode, in a restaurant, two characters (Junior and Vadim) linked to the investment world discuss the construction of a casino in the Arctic region. In the table below, we describe and analyze part of this scene. For reasons of space, we have taken the liberty of transcribing only some shots.

Table 4

Restaurant Dialogue – Scene analyzed from Extrapolations (2023), Episode 1, Season 1 [Start at: 00h 10min 52sec; End at: 00h 12min 21sec].

Shots	What is seen	What is heard (Caption)
1. EWS – Extreme Wide Shot	Through a door, a restaurant room is revealed with several tables with food, two men talking and looking at each other at one of them.	**Junior:** We already have three thousand reservations. Did I tell you who did the decoration?
5. ECUS - Extreme Close-up Shot	Focused on the top of the table, with cutlery, glasses, and plates. Vadim's hand appears moving a tablet, where a small hologram is projected.	**Vadim:** I set up a schedule. From the start of the work to the inauguration, nine months.
6. MS - Medium Shot	The two men are sitting and talking. In the background, a medium-sized window facing the street is visible. At the end of his speech, Junior turns the hologram off. At that moment, several protesters appear on the street, visible through the window.	**Junior:** A wise man once said, "It doesn't matter what excavators and dump trucks do, as long as they do a lot of it". Can you believe them *[the protesters]*? I don't even know how they march, they're so stupid.
7. MS - Medium Shot	The two men sitting and talking look towards the window, observing the protesters. Soon after, they look at each other again.	**Vadim:** They say the ice in Greenland is going to break up.
8. MCUS - Medium Close-up Shot	Junior is framed. He speaks with gestures and a "disdainful" expression.	**Vadim:** The 79N ice sheet. **Junior:** Great, let's build there later.
9. MCUS - Medium Close-up Shot	Vadim is framed. In the background, out of focus, a woman is seen sitting at another table. Junior is in medium close-up, to the right and with his back turned, out of focus.	**Vadim:** Sea levels will rise 3 meters by the end of the century. **Junior:** "They say"? They said the same thing about Miami.
10. MCUS - Medium Close-up Shot	Junior is framed again. As he speaks, he moves in his chair until his back is off it. Vadim is in medium close-up, to the left and with his back turned, out of focus. At the end of his speech, Junior stands up and goes to the window to look at the protesters.	**Junior:** We make a lot of money by retrofitting the buildings. And guess what? When it goes up a few more inches, we'll renovate this f*%# again and make more money. You just need to know this about global warming: everything will be fu#%*%# by the end of the century. That's for sure. We'll be dead by then, we won't see it, because we'll be smiling in Kanye's golden coffins. (...) The Top of the World Casino will be the best of all (...).

Source: Prepared by the authors (2024).

In shot 8, the character mentions the "79N ice sheet", a large ice shelf located in Greenland that is particularly relevant due to its potential impact on sea level rising as the Earth's temperature continues to elevate, contributing to its melting. This mention allows for the exploration of scientific concepts, such as how ice sheets work and the mechanisms of glacial melting. It also expands the approach of methodological aspects of science, such as the use of satellite images and how to detect melting and global temperature rise, in addition to emphasizing the social impacts associated with sea level rising. These are elements present, for example, in Visions I and II of SL.

In the dialogue between the characters, we also notice a clear prioritization of their monetary interests, demonstrating disregard for the possible environmental

impacts of their actions. In shot 10 of the scene, we can note the character making a blunt statement, which shows his willingness to prioritize construction and profits regardless of the environmental consequences. His speech demonstrates a negligent attitude towards intergenerational responsibilities by stating that there is no need to worry about global warming, since they will already be dead.

The scene is predominantly composed of shots that frame the characters close to the camera (MS and MCUS), as if the viewer were sitting at the restaurant table, contributing to an intimate atmosphere, making the audience enter the work and share the characters' emotions (Gerbase, 2012). In cinematographic terms, this observation is important, since each scene awakens different sensations in those who watch it (Bueno & Silva, 2018). Thus, they are relevant for motivation and for "controlling elements of the viewer's identification with the characters" (Turner, 1997, p. 58, our translation).

The speech shown in the excerpt described is reinforced in some other scenes of the episode, such as in the statement by the character Nicholas Bilton (00h 29min 42sec): "it's easier to negotiate with a man whose house is on fire" (our translation from the captions). This speech symbolizes his strategy of taking advantage of environmental crises (forest fires) to facilitate his negotiations with countries and organizations that are in a state of vulnerability, maximizing his corporate interests. The scene illustrates and highlights the dynamics of power, economic exploitation, and environmental injustice. To contextualize, Bilton is a multimillionaire and CEO of the fictional company Alpha, besides being one of the main characters in the series.

In addition to enable discussions about aspects of ethics and environmental legislation, these scenes also allow for the problematization of conscious, critical and responsible attitudes in the world in the face of socio-environmental challenges and impacts – which are relevant issues in Scientific Literacy, as discussed by Souza and Pinheiro (2018) and Bicalho, Farias and Arrais (2024).

We also highlight episode 3, which takes place in the year 2047. Its narrative focuses mainly on the city of Miami, which is facing constant flooding due to climate change. The narrative explores, in an intense and detailed way, the impacts of this crisis on society, among which we highlight three: (i) to go out into the streets and attend the religious temple featured in the episode, people need to wear galoshes, since the waters reach almost up to their shins; (ii) inside the temple, there is a machine equipped with humidity sensors and water pumps, trying to drain the large amount of accumulated water; and (iii) aerial scenes of the city are shown, with streets and neighborhoods completely flooded, damaged and uninhabited buildings, while a narrator describes streets closed off due to the floods and reports that the humidity in the air has reached 70%.

Regarding this episode, we present, in the table below, the description of a scene in which two characters are talking: Marshall Zucker and Harris Goldblatt, a rabbi and a businessman, respectively.

Table 5

Dialogue in the synagogue - Scene analyzed from Extrapolations (2023), Episode 3, Season 1 [Start at: 00h 35min 23sec; End at: 00h 36min 08sec].

Shots	What is seen	What is heard (Caption)
1. CS – Cowboy Shot	In the medium close-up shot, Marshall is back turned. In the background, facing the camera, there is Harris. The scenario shows pictures on the wall and a bookshelf with papers.	**Marshall:** What have you gotten me into? **Harris:** For someone to win, someone has to lose. I think that's what the Torah says.
2. MS - Medium Shot	Marshall standing. Around him, elements of the room (paintings, bookshelf, and folders).	**Marshall:** No, that's how it is in basketball, not in the Torah.
3. MS - Medium Shot	Harris standing, hands in his pants pocket. Around him, elements of the room.	**Harris:** For the record, I didn't know it was either the synagogue or the homeless center...
4. MS - Medium Shot	Marshall stood there, looking disapproving and perplexed.	**Harris:** ...and the State cannot save everything, Rabbi.
7. MCUS - Medium Close-up Shot	Harris speaking in the same position as in previous shots.	**Harris:** I don't mean to be rude, Rabbi, but technically speaking, they're already homeless. Can't they just stay anywhere?
8. MCUS - Medium Close-up Shot	Marshall, in the same position as before, reinforces his expression of disbelief in Harris's speech.	**Harris:** We won, rabbi. Focus on that. Think of the good you can do now that we are safe.

Source: Prepared by the authors (2024).

After shot 8, the character Harris leaves the room and the scene ends. This scene described occurs shortly after a homeless man accuses the rabbi of having abandoned the people who trusted him. The episode describes a "political deal" in favor of the synagogue – a deal that was mediated by Harris, a character who ends up being arrested at the end. Specifically in shots 4 and 7, we can note, in Harris's speech, the neglect of certain segments of the population in the face of climate and social challenges. Despite the catastrophic scenario, financial agreements are prioritized, even if this leaves the population vulnerable and homeless. These elements reinforce, once again, the possibility of reflecting on the use of science for the benefit of the population and social transformation, in line with the SL perspective defended by Valladares (2021).

The series is effective and compelling in presenting potential future scenarios marked by drastic changes caused by climate issues. In addition to the previous examples of Miami, several other scenarios are imagined, such as episode 5, which takes place in 2059, in Mumbai, where people are forced to pay if they want to breathe a cleaner air, using street stalls equipped with "respirators" similar to inhalers (Figure 1). In addition, the episode also shows people selling drought-resistant seeds.

Figure 1

Respirator in the city of Mumbai, shown in episode 5.

Source: Apple TV +, available at:
https://www.apple.com/br/tv-pr/originals/extrapolations/episodes-images/

These extrapolations, which involve scientific and technological scenarios with a direct impact on people's lives, are striking characteristics of the Science Fiction genre, as already discussed. We understand that these elements are important to provide and promote Scientific Literacy, as they offer an opportunity to reflect on possible applications of scientific knowledge in an ethical, fair, and critical way.

We point out that these debates, facilitated by Science Fiction, can be articulated with real cases that occur/occurred in the national and international scenario, that is, concrete problems faced by society. Recent examples, such as the devastating floods in Rio Grande do Sul in 2024, hurricanes Otis (in 2023) and Milton (in 2024), the uncontrolled fires in Brazil in 2024, and the dam ruptures, such as Mariana (MG), in 2015, highlight the urgency of these discussions. We understand that these situations are similar to the themes addressed by the series under analysis, demonstrating how Science Fiction can serve as material for reflecting on socio-environmental challenges and their possible implications for the future.

We will mention one last example, which provides, in addition to discussions about ethics and the impacts of science on society, an approach to the conceptual content of science. In episode 4, which takes place in 2059, we see the character Gita Mishra developing a geoengineering plan to combat climate change. The plan consists of releasing massive quantities of particles, such as calcium carbonate, into the atmosphere in order to lower the planet's temperature. The method, however, raises some doubts since it is not possible to know whether unpredictable effects will be triggered. Events involving volcanic eruptions and how their ash cools the Earth are also reported as inspiration for the plan.

From this scenario, it is possible to focus attention on the approach of conceptual content and natural phenomena, such as chemical reactions in the atmosphere, volcanic eruptions, cooling systems, pollutants, technologies, and projects related to geoengineering, among others. This entire narrative is built around discussions and political intrigues about whether to adopt the plans proposed by the character or not, which opens space for strategies that, as discussed by Bicalho, Farias and Arrais (2024), train people engaged in debates on environmental public policies and that aim for solutions based on evidence and sustainable practices.

With the cases mentioned in our brief analysis of the series, and based on Viana's (2012) propositions, we realize that the series adopts the "verisimilitude"

mode of signification, that is, the way it conveys its message seeks to be as realistic as possible, in order to make it apparently real. Two of the main messages conveyed and discussed refer to how capitalist ambitions can be responsible for environmental crises and what are the main impacts of these crises on society.

Lastly, we highlight that, since this is a production in the series format, its duration may be a possible difficulty in using it in the classroom. It would be difficult for a teacher to show all eight episodes during classes, thus requiring the adoption of some strategies, such as selecting only a few episodes or showing specific excerpts, taking care to preserve essential elements that contextualize the narrative. In any case, as Oliveira and Nunes (2022) indicate, the use of series in teaching has been discussed in several studies, which highlight benefits of use, such as interdisciplinarity, contextualization, facilitating the understanding of abstract concepts, building critical thinking and proximity to students, since many of them have contact with this type of media production.

FINAL CONSIDERATIONS

This study aimed to identify and analyze the socio-environmental issues present in Science Fiction works that could provide opportunities and promote the development of Scientific Literacy. In general, we sought to find connections and relationships between these themes from the analysis of some works of the SF cli-fi subgenre.

The analyses carried out indicate the presence of several significant aspects for the socio-environmental approach based on SF. In these narratives, we can note, for example, the presence of scientific concepts, even if, due to the characteristics of the genre, they are sometimes shown in an extrapolated way. There is also a noticeable concern about the impacts of environmental degradation on humanity and social relations. Complex themes, such as environmental injustice, inequalities, the need to break down structures of oppression, and ways of life and systems that aggravate environmental degradation are also themes addressed by the works analyzed, which makes it possible to approach them with a critical and transformative perspective of Science Education.

We agree with Borba (2015), who emphasizes that movies are not educational productions, since they are produced in another context, encompassing an artistic, cultural and market project. The author also indicates that, if they are shown in schools, it is because this was made didactic. Therefore, we must consider that films and series, by themselves, probably do not develop Scientific Literacy. The teacher must use these works intentionally, in order to create scenarios and possibilities capable of providing this development. As seen in the research, these works present several elements and characteristics that can be useful and relevant to this process.

We therefore assume that the use of Science Fiction works in Science Education, aiming to address socio-environmental issues from the perspective of Scientific Literacy, must be done critically and contextualized by the teacher, emphasizing the problems and situations related to social, cultural, political, environmental and conceptual issues present in the work – and not just for recreational purposes.

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