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Analysing the Storyline Approach's Competence-Developing Potential for Climate Change in Science Education

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Abstract. Climate Change is the greatest threat to mankind and the biosphere. It challenges Science Education from many points of view, including searching for effective ways to enable citizens to make decisions, embrace complexity, deal with uncertainty and envision possible futures. Two approaches are used to assess the influence of Anthropogenic Climate Change in extreme weather events: the so-called risk-based approach and the storyline one. In this study, we compared these two approaches from a Science Education point of view to understand if they have the same potential to develop sustainability competences in secondary school students.

1. Introduction

Climate Change (CC) is considered the greatest challenge to humans and the biosphere (IPCC 2021), and in the need to prevent planet Earth's ultimate destruction (DeBoer 1991) scientific literacy (Yacoubian 2018) can be seen as a strong tool to promote sustainability and sustainable development for citizens, policymakers and stakeholders (UNESCO 2017). Between CC researchers, IPCC (Intergovernmental Panel on Climate Change) has become in the last thirty years the most important organ for delivering information and forming about the science of CC and its impacts. In the last reports, however, there has been a change in the approach they used to present data for researchers and policymakers (IPCC 2014, 2021). This change regards the approach used to treat uncertainties and develop future scenarios and also originates from a debate that formed in the detection and attribution [D&A] of extreme weather events in recent years (Shepherd 2016, 2019; Shepherd et al. 2018; Stott et al. 2004; Stott et al. 2013; Stott et al. 2016; Trenberth et al. 2015).

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Two main approaches have been used in D&A of extreme weather events: the first is the risk-based approach, the best-known and most widely used approach, and the second is the storyline approach. The introduction of this second approach has stimulated vivid debates not only among climate scientists, in that the two approaches are based on different assumptions and cohere with different conceptions about the nature of science and the role of probability in climate-related events. Because of its socio-political relevance, the debate has been also involving policymakers and philosophers of science (Lloyd and Oreskes 2018). This paper aims to enter the debate from an educational perspective and unpack its implications for science teaching and communication. Specifically, the peculiarities and differences between these two approaches are analysed in terms of their potential to develop competences for sustainability, as recommended by the European Union (Bianchi et al. 2022).

2. Climate Change Education

Science and Science Education can be characterized both as a cognitive-epistemic and socio-institutional system (Erduran and Dagher 2014). Scientific literacy is considered a major goal of Science Education to promote decision-making at a personal and a societal level (Yacoubian 2018) to face modern-day challenges. Science Education has the potential to play a primary role in enabling the development of a critical vision that is at the same time capable of adapting to and dealing with the challenges of tomorrow (Levrini et al. 2019). The search for effective ways to situate and address CC within school curricula is a more and more urgent goal since schools can play a crucial role in promoting change at a plurality of levels: knowledge, skills, and attitudes. A comprehensively different stance toward CC is necessary to make future citizens capable of holding positions of power with the possibility to change for the better world they will live in (Grayson 2020). More generally, Climate Change Education (CCE) "can be a strategic and meaningful entry point for promoting the principles and practice of sustainable development through education" (Mochizuki and Bryan 2015, p. 5). Over the past decades, since the first CC studies appeared in the scientific landscape, the number of CC courses in schools has increased exponentially. According to a literature review conducted for "Climate Change Education" research articles (Monroe et al. 2019), the number of articles went "from 12 articles published between 1990 and 1999, and 433 from 2000 to 2009, to 1489 from 2010 to 2015" (p. 1). The authors found 49 papers addressing effective CCE strategies in their review. Most of these courses focused on personally relevant and meaningful information (Bofferding and Kloser 2015; Wibeck 2014) and used active and engaging methods (Bybee et al. 2006; Jacobson et al. 2015; Walsh and McGowan 2017).

In the field of research on the societal implications of CC and the role of human influence on it, the main references for environmental policies are the reports of the IPCC. IPCC studies CC and its nature and produces reports aimed at both the

scientific and the societal levels. If in the Second Assessment Report (SAR) the role of human influence in influencing climate (Anthropogenic Climate Change, ACC) was defined as "discernible" (IPCC 1995), in the Sixth Assessment Report (AR6) is stated that "it is unequivocal that human influence has warmed the atmosphere, ocean and land" (IPCC 2021, p. 4). The role that humankind has played in the changes over the past 150 years has now been defined as certain (IPCC 2021).

The role of the IPCC over the years has changed from trying to provide scientific proof of the anthropogenic origin of CC to providing governments with information and recommendations to prevent and mitigate the effects of CC (Hulme 2023). To do so, IPCC scientists need to use the language of uncertainty, in that full predictability of future climate events is not possible due to the intrinsic nature of climate. This necessity has been used by many CC contrarians to underscore the actual state of knowledge, as for them "action cannot be taken until knowledge is complete" (O'Reilly 2023, p. 160). The language of uncertainty has then been refined, formalised and reviewed to align all the Working Groups through different guidance for IPCC authors, to delineate and present a common approach to uncertainty (See, for example, Reisinger and colleagues (Reisinger et al. 2020). Different approaches and modalities of presenting and using uncertainty terms have been used in the reports (O'Reilly 2023). In the last reports in particular there has been a shift in the way uncertainties were considered and scenarios were created, leading to the construction of Shared Socioeconomic Pathways (SSP) where qualitative and quantitative elements are used to create alternative future worlds (Nikoleris et al. 2017). SSP narratives contain both qualitative descriptions of large world region trends and quantification of key variables to integrate different models for assessment and vulnerability (O'Neill et al. 2017) and "are intended as descriptions of plausible future conditions that can provide the basis for a range of scenarios to emerge" (Nikoleris et al. 2017, p. 309). These narratives are created to allow policymakers and stakeholders to make decisions by pondering different levels of sustainable behaviours for the future. This goal, therefore, dovetails with those that researchers in the field of Science Education have been trying to achieve for years, namely, to develop classroom practices and useful approaches to best educate toward CC and develop and promote sustainability competences.

Very recently, an official European sustainability competences framework, the GreenComp, has been developed by the Joint Research Center (JRC) of the European Union (Bianchi et al. 2022). GreenComp takes from a wide Science Education literature that addresses the role of science in shaping society (Bianchi et al. 2022; Irzik and Nola 2011; Lotz-Sisitka et al. 2015; Sjöström et al. 2017;).

In GreenComp sustainability is defined as the intent of prioritising all life forms in everyday activities to not exceed planetary boundaries. Rockström and colleagues selected nine planetary boundaries whose limits "define the safe operating space for humanity" (2009, p. 472). These boundaries are biodiversity loss, atmospheric aerosol loading, chemical pollution, CC, ocean acidification, stratospheric ozone depletion, nitrogen and phosphorus cycle, global freshwater use and change in land use. Three of these limits have already been passed, i.e. biodiversity loss, nitrogen cycle, and especially CC (Rockström et al. 2009). There is therefore a need to promote sustainable behaviours in society to prevent the further passing of these boundaries. GreenComp identifies twelve sustainability competences "to feed into

education programs to help learners develop knowledge, skills and attitudes that promote ways of think, plan and act with empathy, responsibility, and care for our planet and public health" (Bianchi et al. 2022, p. 2). GreenComp is supposed to be an important reference for designing activities and modules for CC Education, to make learners and educators competent concerning sustainability issues. The four areas and twelve competences described in the GreenComp are: Embodying sustainability values (Valuing sustainability; Supporting fairness; Promoting nature); Embracing complexity in sustainability (Systems thinking; Critical thinking; Problem framing); Envisioning sustainable futures (Futures literacy; Adaptability; Exploratory thinking); Acting for sustainability (Political agency; Collective agency; Individual initiative) (Bianchi et al. 2022). The competences present in GreenComp have been addressed already in Science Education literature (Duit et al. 1997; Erduran and Dagher 2014; Laherto et al. 2023a; Rasa and Laherto, 2022). Laherto et al. (2023b) showed this in detail. As with any political report of recommendations, its role is to provide some orientation. Decisions about educational approaches, contents, methods, and strategies to develop these competences are up to the implementer stakeholders (researchers, teachers, principals, national and local policymakers, and so on). Being CC one of the nine planetary boundaries to preserve to achieve a sustainable way of living, in this study GreenComp is used as a reference framework to confront different methods usually used to describe, present, narrate and understand CC and compare their educational potential for sustainability training and developing of decision-making.

The approaches discussed in this study are the risk-based approach and the storyline, between which there has been a debate about the foundations of the scientific method and the role of research for society in detection and attribution (D&A) regarding extreme weather events with a big potential for educational purposes. The approaches are used for determining the impact of a specific factor over a multitude of possibilities, the first based on the concept of risk (Allen 2003; Stott et al. 2004; Stott et al. 2013; Stott et al. 2016) and the second that relies on storylines construction (Hoerling et al. 2013; Shepherd 2016; Shepherd et al. 2018; Shepherd 2019; Trenberth 2011; Trenberth et al. 2015). These two approaches have been pitted against each other by various experts in the field because they are apparently divergent in the method used to provide answers in the case of detention and attribution of extreme weather events (Allen 2003; Lloyd and Oreskes, 2018; Trenberth 2011). Before getting to the heart of the debate and its educational potential, we present the two approaches and their characteristics in in more detail.

3. Risk-based approach and storyline approach

The risk-based approach estimates the change in the likelihood of a certain effect arising from the presence of a certain factor. "Event attribution assessments seek to quantify to what extent anthropogenic or natural influences have altered the probability or magnitude of a particular type of event having occurred" (Stott et al. 2016,

p. 25). Three steps are fundamental for obtaining relevant data using this approach: to define the event, to construct a factual likelihood distribution for that event using a model, and then to construct a counterfactual distribution with which to compare the factual distribution (Shepherd 2016, p. 30-31). CC effects are then calculated in the altered frequency of a class of events of a particular magnitude or the altered magnitude of a class of events having the same frequency in the factual world. This way of approaching the problem of event attribution by estimating the *fraction of attributable risk* (FAR) of climate extremes was first introduced in 2003 and used to address the European heat wave of 2003 (Allen 2003; Stott et al. 2004). Over the years it has developed as the main method for D&A of extreme weather events. In the FAR model, there is an estimated probability of a certain class of events related to the world as we see it today (*p1*), also called the factual world and a probability of the same class of events in a counterfactual world (*p0*) in which the estimated role of humankind in contributing to CC (ACC) is removed. The ratio of *p1* to *p0 (*Risk Ratio*, RR=p1/p0)* says at what level that class of events is more or less likely interpreted as the result of human forcing. Because FAR is defined as *1-p0/p1*, the threshold above which an actual human contribution to CC can be evidenced is 0.5 (Stott et al. 2016).

If this process can be reliable at a global scale when discussing thermodynamic aspects like temperature changes or sea surface temperatures (SST), the situation changes when dynamic aspects involve the atmospheric or oceanic circulation. At a regional scale, "the thermodynamic aspects are strongly modulated by the dynamic aspects so the latter must be taken into account" (Shepherd 2016, p. 32) and these are connected to high levels of uncertainties.

Storylines are defined as "physically self-consistent unfolding of past events, or plausible future events or pathways" (Shepherd 2016, p. 2). The storyline approach has been introduced and used for the first time by Trenberth and colleagues (2015), and one of the first examples can be seen in assessing the Texas drought of 2011 by Hoerling and colleagues (2013). Storylines "can raise risk awareness by framing risk in an event-oriented rather than a probabilistic manner" (Shepherd et al. 2018, p. 566). They provide a mechanism to improve decision-making by analyzing vulnerability points and partitioning probability factors, combining regional aspects and factors related to CC risk (Shepherd et al. 2018). A storyline-based approach identifies the causal chain of factors leading to a certain event, assessing their roles and their links. To make a so-called storyline one takes the data of a certain extreme event, and makes a kind of "autopsy" of the event (Lloyd and Oreskes 2018). The storyline approach makes it possible to qualitatively attribute the causes of a certain event when it is caused by not well-known dynamic factors and not only thermodynamic ones (Shepherd 2016). Through a Bayesian method, and thus the identification of causal links between events, it is possible to construct a causal network capable of highlighting areas where actions can be taken (Shepherd 2019). According to Trenberth and colleagues (2015) in those situations where a risk-based approach brings high-uncertainty results, it can be useful to physically investigate the unfolding of the events, trying to determine how each factor may have been affected by known thermodynamic aspects of CC (Shepherd 2016). Tracing the succession of certain events by determining their causes can help in predicting and preventing that event from occurring again with the same consequences and results. The storyline-

based approach does not address the potential change in the probability of the dynamic situation that resulted in the event but can tie attribution directly to the observed event, rather than just being probabilistic in a frequentist sense (Shepherd 2016; Trenberth et al. 2015). “The direct confrontation with data as an essential component of the attribution is a very attractive feature of this approach, as is its emphasis on a physically based causal narrative” (Shepherd 2016, p. 34). Examples of this approach can be found in literature (Hazeleger et al. 2015; Hoerling et al. 2013; Trenberth et al. 2015).

4. Methodology

The aim of this paper is to understand the potential of developing sustainability competences of the two approaches from a Science Education perspective. To do so, we reviewed the risk-based and the storyline approach through the lenses of GreenComp, as we tried to evaluate if and how each competence was present, addressed and promoted.

To realize the study we focused on the papers that used the approaches directly (Allen 2003; Hoerling et al. 2013; Shepherd 2016; Shepherd et al. 2018; Shepherd 2019; Stott et al. 2004; Stott et al. 2013; Stott et al. 2016; Trenberth et al. 2011; Trenberth et al. 2015) and on the papers that discussed the philosophical, societal and ethical implications of the approaches (Allen, 2011; Curry, 2011; Lloyd and Oreskes, 2018; Mann et al., 2017). Each competence has been transformed into a specific guiding question (Table 1). The guiding questions have been used to navigate both the original papers and those that alimented the debate between the approaches. To conduct this focused reading, we looked for some particular keywords inside the papers mentioned above. For some of the competences, the keyword is the name of the competence itself, while for others we choose particular words that we consider representative of the competence. The keywords used for the analysis are also reported in Table 1 and are taken from the definitions given in the GreenComp. Both singular and plural versions were considered for the analysis. Keywords formed by two words have been searched in combination using the logic function ‘AND’ and not ‘OR’. The analysis doesn’t aim to provide a count of the number of times a certain keyword appears in a paper but rather to discuss if and how certain keywords are considered in the papers when discussing the approach.

Each approach has been analysed through the lens of these twelve questions and the related keywords. The results of this analysis are presented in the next section. These results are also used to present in detail the different points of view of the debate between the approaches.

Table 1 Competences, guiding questions and keywords based on GreenComp (Bianchi et al. 2022) competence definitions

Areas	Competences	Guiding Questions	Keywords
Embodying sustainability values	Valuing sustainability	What kind of values are promoted? How do they align with sustainability values and ethics?	Values, sustainability, ethics
	Supporting fairness	Does the approach support equity and justice for all?	Fairness, equity, justice
	Promoting nature	Is the approach capable of promoting respect towards other species and nature itself to restore and regenerate healthy ecosystems?	Respect, nature
Embracing complexity in sustainability	Systems thinking	Does the approach help in tackling sustainability problems from all sides and focusing on how the elements interact within and between systems?	System thinking
	Critical thinking	Is the approach useful for promoting reflections about information, assumptions and the influence of social and personal backgrounds?	Critical thinking
	Problem framing	Does the approach help to formulate challenges as sustainability problems based on social, economic and territorial aspects to anticipate and prevent present and future challenges?	Problem framing
Envisioning sustainable futures	Futures literacy	Is the approach capable of generating alternative sustainable futures through imagination and the development of scenarios?	Futures literacy
	Adaptability	Does the approach help in managing transitions and challenges and in making future decisions in the face of uncertainty, risk and ambiguity?	Adaptability
	Exploratory thinking	Does the approach facilitate the adoption of a relational way of thinking by using creativity and experimentation?	Exploratory thinking, creativity
Acting for sustainability	Political agency	Does the approach help in identifying political responsibility and accountability?	Political agency, decision making
	Collective action	Is the approach useful for promoting action for change in collaboration with others?	Collaboration
	Individual initiative	Does the approach contribute to identifying one own potential to actively improve one's role in the community?	Initiative, attitude

5. The study

We now discuss the results we obtained through the focused reading in terms of how the two approaches relate to each sustainability competence.

Regarding sustainability values and supporting fairness, the papers do not address directly the values promoted by each approach, but Lloyd and Oreskes (2018) showed how the two approaches differentiate themselves in terms of type I (i.e. false positive) or type II (i.e. false negative) errors, and therefore taking decisions of preferentially guarding against one or another is a question of values rather than a scientific one. Committing a type II error, i.e., a false negative, allows researchers to avoid exposure in the case of wrong predictions and to avoid unnecessary expenses and costs to prevent and prepare for extreme events that may never happen (Lloyd and Oreskes 2018). But at the same time, this choice puts at risk those exposed to extreme events who have not done adequate prevention and mitigation. According to (Lloyd and Oreskes 2018; Shepherd 2019; Trenberth et al. 2015), drawing parallels with the research that is carried out in the medical field for testing medicines and vaccines, it would be more appropriate from an ethical point of view to change the perspective and put the mantra of "do no harm" first. In the case of medical research, scientists need to verify both that the drug is effective, but also that it does not cause unwanted effects (Lloyd and Oreskes 2018). It then becomes necessary to understand which harm is most desired to be avoided in the case of D&A of extreme weather events. It has been shown that people are more forgiving when false alarms are made, rather than missed warning calls (Economou et al 2016). Regarding promoting nature, no related keywords were found in the papers. Nonetheless, both approaches are aimed to improve the D&A process and to better describe extreme weather events to help society in dealing with them. The preservation of our ecosystem is a specific purpose of the detection and attribution process without distinction between approaches, as understanding the human role in influencing the climate is the necessary point to identify those activities that foster this influence.

Regarding “Systems thinking”, the possibility of constructing causal networks to establish the role of each particular event as in the storyline approach can be useful for developing connections across systems. Being the climate a complex system, facing extreme weather events using a frequentist approach based on many factors could lead to a non-clear definition of the interaction between different elements. The frequentist approach is widespread in the scientific community but doesn’t have deep roots (Mann et al 2017), leading many scientists to re-examine the appropriateness of such an approach for hypotheses testing (Nuzzo 2014). “The result of bad and misleading statements about attribution, of which there have been many, is to grossly underestimate the role of humans in climate events of note in recent times to the detriment of perceptions about Climate Change and subsequent policy debates” (Trenberth 2011, p. 929). A Bayesian approach instead assumes, starting from many considerations on CC (Trenberth et al 2015), that “Climate Change is likely to be impacting extreme weather events” (Mann et al 2017, p. 133) as a prior. This approach proves much more useful in cases where there are aspects of the problem detectable with a certain high probability (e.g., thermodynamic aspects)

and others much more uncertain (e.g., dynamic aspects) (Mann et al 2017) but may lead to type I errors (Lloyd and Oreskes 2018). This could be also because the fundamental use of simulations and models requested by the risk-based approach can generate a black-box effect hiding important systems relations. Through the Bayesian approach and the assumption of the specific dynamics related to a certain event (past or future), the storyline approach helps in generating connections between factors (Shepherd 2019) and understanding the role of each one of those. Working with complexity has been shown to have a great potential to provide citizenship skills to navigate society (Barelli et al. 2018; Cilliers 1998; Morin 2003).

As for critical thinking and problem framing, there is a distinction between the two approaches that regards the ways of treating uncertainties. Unlike in the risk-based approach, in the storyline, a distinction is made between different types of uncertainty related to climate phenomena and extreme weather events. As explained in detail by Shepherd (2019) and Dessai and Hulme (2004), climate phenomena are marked by three different types of uncertainty: uncertainty in future climate forcing, which is the different scenarios that try to predict different types of futures, called reflexive uncertainty (Dessai and Hulme 2004); uncertainty in climate response to future climate forcing, which is known as epistemic uncertainty; and uncertainty in the actual realization of climate in a certain time window, called aleatoric uncertainty (Shepherd 2019). In the division of the factors that led to a certain event, the storyline approach makes explicit distinctions between the aspects connected to science, those connected to nature and those connected to humans. To promote action, an approach such as the storyline approach is more suitable than a risk-based one. In the storyline approach much distinction is made between epistemic and aleatoric uncertainty, whereas in the risk-based approach, these uncertainties are often considered together (Shepherd 2016). This distinction can help in addressing the different responsibilities that each one can have in preventing or facilitating a certain event, and therefore in framing extreme weather events under a different light based on the related type of uncertainty.

The competences presented in the "envisioning sustainable futures" area are also strictly related to the different ways of treating uncertainties in decision-making. The distinction between the two approaches stays in the difference between the concepts of forecast and foresight. Forecasting is the process of making predictions using past and present data, as in the risk-based approach. Foresight explores the range of plausible futures starting from a certain point to identify preferable scenarios to reach (Cuhls 2003), as in the storyline approach. Foresight is also tied with the process of backcasting, where the task is to figure out a way to a particular plausible or preferred future, as Laherto and colleagues showed (2023b). The possibility of imagining different future scenarios can therefore help in promoting creativity and experimentation for decision-making, two main aspects of "exploratory thinking". For example, a Future-Oriented Science Education approach that has been produced in recent years (Branchetti et al. 2018; Rasa and Laherto 2022) ties together complexity and future imagination with values through the development of different possible futures.

Regarding the area of "acting for sustainability", the distinction between the two approaches can be analysed through the lens of the three spheres of change model proposed by O'Brien and Sygna (2013). This model expresses the need to work at

the same time on three distinct levels (practical, political, and personal) to promote a deep transformation for achieving the necessary sustainability goals for our society. When facing a wicked problem such as CC or others demanding socio-scientific issues, there is a tendency to extremize the dichotomy between the individual and the collective dimension of problems (Barelli et al. 2022). The possibility given by the storyline approach of distinguishing between the several factors that are tied to a particular extreme event, and therefore the possibility of generating a causal network to separate the different levels of intervention (Shepherd 2019) can be a strong incentive for promoting action both at the individual and collective level. Also, stakeholders or policymakers and scientists may respond to different types of information. This aspect is tied to the possibility of the storyline approach focusing more on local events and therefore facilitating the decision-making process. The storyline approach is case-specific, referring to well-defined events that have already had local consequences and thus it succeeds in being more effective at the time when decisions need to be made to prevent the event from recurring with worse consequences. As Shepherd noted, "It may be difficult to convince people to invest in defences against a hypothetical risk, but easier to do so if an event has previously occurred so clearly could occur again, but potentially with more impact" (Shepherd 2016, p. 33). In the case of risk-based, on the other hand, there is a focus on classes of events, which can be categorized as unlikely or very likely within ranges that are too wide to allow an effective decision to be made (e.g. unlikely corresponds to a 33% chance) (Shepherd 2019).

In light of these differences, several researchers inferred that the two approaches are incompatible and that the storyline approach challenges what the scientific community assumed was right in the past, i.e., preferring type II to type I errors (Allen 2011; Curry 2011; Lloyd and Oreskes, 2018). This debate can be seen in detail in Lloyd and Oreskes (2018), in which the authors analyse the debate showing how the two approaches are compatible and complementary as they answer two different research questions: if the FAR methodology's research question is "what are the odds or probabilities of a particular class of events, given changes in climate compared to historical pre-industrial or counterfactual climate?" (Lloyd and Oreskes 2018, p. 313), the research question the storyline approach tries to answer is "given the atmospheric dynamics about the event, how did climate change alter it?" (Lloyd and Oreskes 2018, p. 313). According to the authors, the choice of one approach over another lies in the preference and the decision that needs to be made about which risk is of greater concern. This discussion is based on several aspects, namely, what is the role of scientists in research, what role scientists have in society, what kind of information needs to be passed to the public, and what values are tied to this information passage. In cases where information needs to be passed to other researchers, local stakeholders, policymakers or laypeople, it is crucial to understand what kind of information to present and for what purpose. Likewise, from an educational perspective, it is necessary to understand which approach is most effective in enabling a more adequate understanding of the phenomenon of CC and the training competences necessary for sustainable development.

5. Storyline-approach for Climate Change in Physics Education

As stated by Lotz-Sisitka and colleagues (2015) and UNESCO (2017), there is a request for a rethinking of values and purposes to develop transformation in individuals and society. Sjöström and colleagues (2017) expressed the need for science education to directly support value-based transformative agency. As discussed above, the two approaches offer different stances and positions about the four competence areas. On the value level, the two approaches are both useful in promoting awareness toward sustainability issues, with the storyline more focused on the safety of people while the risk-based focuses more on the accuracy of statements and assumptions. Regarding complexity, the storyline looks closer to the requests coming from the Science Education literature on developing skills for reading complexity in everyday life. The complexity of climate systems is fully addressed within the storyline approach, allowing the reconstruction of the links between the different factors that led to the occurrence of a certain event, while in the risk-based approach, this possibility is limited by the extensive use of models and simulations that can prevent a clear view of the mechanisms at play unless specific advanced knowledge is available. Regarding the future, the distinction between forecast and foresight helps in creating plausible scenarios rather than making predictions, leading to a possible enhanced capacity for making decisions and creating policy plans. To promote action, an approach such as the storyline approach is more suitable than a risk-based one, in that the clear division between the different types of uncertainty present within the storyline approach, along with the reconstruction of causal networks, allows for clear identification of which aspects can be acted upon. In this way, one goes to act on aspects of systemic thinking that are not touched upon in the risk-based approach instead.

Building on these methodological and epistemological differences, we infer that the storyline approach is better suited to the development of the sustainability competences presented in GreenComp. Starting from these results, we are now working to test if and how the epistemological assumptions underlying the storyline approach can be implemented and exploited for developing teaching courses and modules. CC touches on deep underlying epistemological and ontological issues about the concept of causality, temporality and prediction. “The widespread misunderstanding of climate change may arise from an error in people’s ontological assumptions” (Chen 2011, p. 31). We are used, due to our cognitive development, to think about processes as objects, therefore preventing us to accept CC as a process (Chen 2011). We hope that the reflections presented above can be seen as a useful tool to differentiate the approaches for educational purposes and used to construct teaching sequences and programmes aimed to promote systemic thinking and generate action. An approach such as the storyline allows one to focus on process characteristics, the actual causes that lead to certain consequences, and possible actions that can be taken with a view to prevention and adaptation. Bringing a similar approach into the classroom and re-reading storylines from an educational perspective could be a way to foster action and enable the development of skills needed to promote sustainable development.

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