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Contents

A better place for whom? Practitioners' perspectives on the purpose of environmental education in Finland and Madagascar

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A B S T R A C T

Calls for a common environmental education (EE) vision imply imposing certain values as universal. Nevertheless, there is a lack of knowledge on textent to which E reflects universalities versus diverse sociocultural realitiesWe explored practitioners' perspectives on the purpose of E by interviewinpractitioners in Finland and Madagascar using a theory of change approach. We classified E goals into eight categories following the framework of Claet al. (2020). We found signs of universal patterns, with commonalities such as the importance of the cognitive domain and de-emphasis of sociocultural aspects. Yet, differences arise: the connection to nature was central in Finland, whereas economic and bridging strategies were more common in Madagascar. Our results reflect the tradition of E in post-industrial countries and suggesthe influence of the colonial legacy and Western epistemologies in Madagascar. Questions remain about the extent to which those differences are culturally grounded.

KEYWORDS:conservation education; theory of change; outcomes; educator; nonformal environmental education; conservation organization

RÉSUMÉ

Pour une vision commune de l'éducation à l'environnement (EE), il faut imposecertaines valeurs comme universelles. On observe cependant un manque de connaissances sur la mesure dans laquelle l'EE reflète les universalités parapport aux diverses réalités socioculturelles. Nous avons exploré les perspec tives des praticiens sur l'objectif de l'EE en interviewant des praticiens eFinlande et à Madagascar, en utilisant une approche de la théorie du changement. Nous avons classé les objectifs d'EE en huit catégories, selon le cadrde Clark et al. (2020). Nous avons trouvé des signes évocateurs de modèlesuniversels, avec des points communs, comme l'importance du domaine cog nitif et la désaccentuation des aspects socioculturels. Pourtant, des différences apparaissent: le lien avec la nature était central en Finlande, tandis que les stratégies économiques et de transition étaient plus courantes à Madagascar. Nos résultats reflètent la tradition de l'EE dans les pays post-industriels esuggèrent l'influence de l'héritage colonial et des épistémologies occidentales à Madagascar. Des questions demeurent quant à la mesure dans laquelle ces différences sont fondées sur la culture.

INTRODUCTION

Environmental education (EE) is considered a key intervention to address the current environmental crisis (Reid et al., 2021). Responding to this global crisis, EE practitioners are committed to making the world a better place. From children to adults, and from classrooms to zoos and parks, EE embraces a range of topics, learner types, contexts, approaches, values, and ideologies (Rickinson & McKenzie, 2020). For some, this diversity can simultaneously play as a drawback. Clark et al. (2020, p. 382) stated that a major obstacle to the overarching goal of EE is “reaching agreement on what constitutes a ‘better place’—or whom, under what conditions, and by what path or paths”.

The UNESCO Tbilisi Declaration (UNESCO, 1977) established that the ultimate goal of EE is to ensure people’s active participation in moving society toward the resolution of environmental problems. Since then, a multiplicity of perspectives have emerged, and groups and organizations have described different aims and priorities for EE (Salazar et al., 2021). At the same time, conservation organizations and intergovernmental agencies have defined frameworks to establish a common vision of EE; for instance, the WWF Global Environmental Education Programme (Huckle, 1988), the UNEP Strategy for Environmental Education and Training (UNEP, 2005), and the UNESCO Roadmap on Education for Sustainable Development (UNESCO, 2020). Similarly, policymakers and practitioners are concerned by the need of “scaling up”, moving education activities from a small to a larger impact, and finding generalizable solutions (Mickelsson, 2020).

However, many environmental educators hold the view that environmental stewardship is neither an innate nor universal value, but it depends on the context where it is learnt and taught (Reid et al., 2021). Along these lines, researchers question the idea of standard educational proposals designed for a diversity of countries, cultures, and peoples, as they imply risks of imposing concrete perceptions of the world and its problems as universal (De Andrade & Sorrentino, 2014). Given the complexity and multiple scales of current socioenvironmental challenges, one of the remaining key questions is how an initiative such as EE is implemented in practice in diverse local social, political, and cultural contexts (Larsen & Brockington, 2018) and whether EE programs are imposing universalized priorities, cultures, and themes (De Andrade & Sorrentino, 2014).

Up to date, the question of why we do EE remains largely unaddressed (Clark et al., 2020) and the few studies that include the views of practitioners focus exclusively on the perspectives of North American practitioners (Clark et al., 2020; Fraser et al., 2015; Salazar et al., 2021). To the best of our knowledge, no previous studies on this topic focus on EE practitioners in the Global South.

Accordingly, the aim of this research is to examine whether the goals and priorities of EE differ in different contexts. To do so, we explore practitioners' perspectives on the purpose of EE in two distinct countries: Finland as an example of a Global North country and global leader on education, and Madagascar as an illustration of a Global South country and a top global conservation priority. Specifically, the focus of this study is on the following research questions:

- What are the goals of EE according to practitioners working in Finland and Madagascar?
- What are the similarities and differences in the purpose of EE between Finland and Madagascar?
- To what extent does the perceived purpose of EE reflect universalities, and to what extent does it reflect different sociocultural contexts?

Theoretical background

In this article, we draw on discussions about the goals and priorities of EE. While the Tbilisi and Belgrade documents from the 1970s are often core reference points, priorities have changed over decades (Reid et al., 2021). Thus, we consider as a starting point the article by Clark et al. (2020) who presented that North American EE professionals and leaders came to agreement on the core outcomes for the EE field, described as: (1) environmentally related action and behavior change, (2) connecting people to nature, (3) improving environmental outcomes, (4) improving social/cultural outcomes, and (5) learning envi ronmentally relevant skills and competencies. These five core outcomes have thereafter been acknowl edged as an established EE framework by other researchers working in the USA and beyond (Bercasio,2021; Bieluch et al., 2021; Dawson et al., 2022; Reid et al., 2021; Tolppanen et al., 2022). For this study, we operationalize core outcomes as a change in the environment or in people's engagement with or actions on the environment. In particular, 'core' means it is a centrally important outcome of EE (Clark et al., 2020, p. 384). Thus, we use Clark's conceptual framework as a tool to frame our analysis and discussion on the various core outcomes of EE.

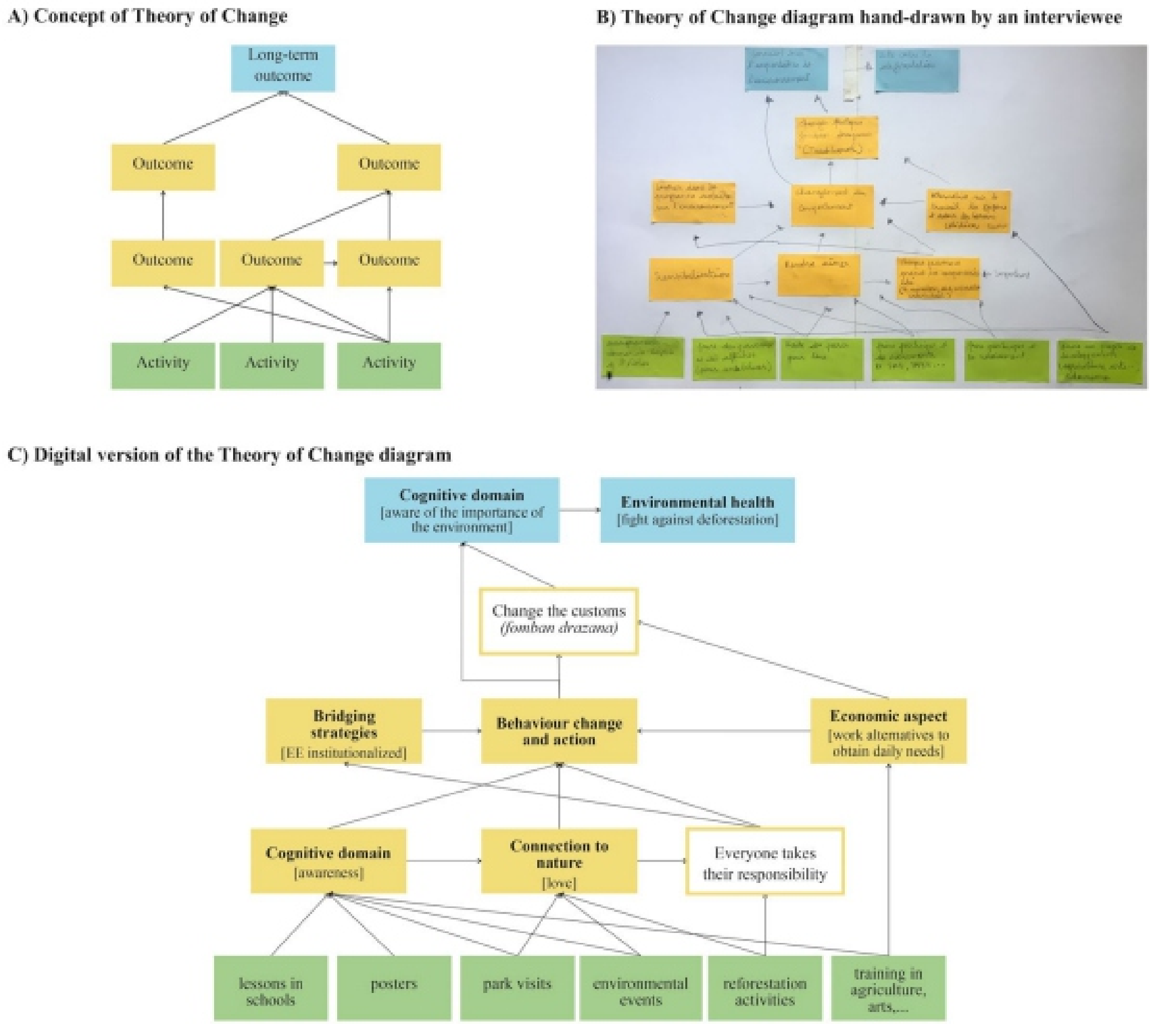

Figure 1. A. Concept of theory of change (ToC): activities in green, intermediate outcomes in yellow and long-term outcome in blue (Adapted from Belcher & Claus, 2020). ToC is created using a backwards mapping process: first, the desired long-term goals; second, the intermediate outcomes; and third, the activities. After defining these three elements, the interviewees draw the arrows to connect the different variables, creating a complex web of assumptions about what needs to happen to bring about change (Center for Theory of Change, 2021); B. Example of a hand-drawn ToC diagram done by an interviewee; and C. Digital version of the same ToC, with the long-term and intermediate outcomes coded according to the classification matrix.

To identify the EE goals, we implement theory of change as a research tool. A theory of change (ToC) is an explanation of how and why an initiative generates a particular change (Belcher & Claus, 2020). Generally, a ToC is expressed as a diagram articulating a network of connections between activities, intermediate outcomes, and long-term outcomes, as exemplified in Figure 1. This tool is widely applied in development organizations for strategic planning and program evaluation (Vogel, 2012), but it is less common in the field of EE. Inspired by the work of Krasny (2020), we use the ToC as a research tool to identify how EE activities lead to outcomes.

Finnish context

Finland is a post-industrial and urbanized Northern European country, and one of the most forested countries in Europe. Most forested areas are owned by private individuals or families and heavily used for logging, but public access to forests is guaranteed by jokamiehen oikeudet (everyone's rights) that gives everyone the basic right to roam freely in the countryside, to camp for a short period, and to pick berries and mushrooms (Rantala & Puhakka, 2020). Old-growth forests are rare, and the species dependent on dead wood are particularly threatened (Blattert et al., 2022). Thus, sustainable forestry is one of the major environmental discourses in Finland.

Finland has a long tradition of EE both as a part of formal education, but also in semiformal and nonformal settings. The Finnish school system has a national curriculum for primary and secondary schools, which is adapted to the local context by the local organizers of the education (Finnish National Board of Education [FNBE], 2014, 2015). The very first national curriculum in the 1920s already included "ethics and morality" as a school subject, which covered topics such as "care for the nature" and "charity towards animals", and emphasized the need for outdoor education, though mostly for the physical edu cation and wholesomeness of the education (Kansakoulun opetussuunnitelmakomitea, 1925). The con cept of "environmental education" was adopted quite quickly after the United Nations Conference on the Human Environment in Stockholm in 1972. The first documented use in a Finnish source was in a dissertation three years later (Leinonen, 1975).

EE in Finland is driven by a focus on young people. In 1985, EE was included as a transdisciplinary topic in Finnish primary and lower secondary school national core curriculum (FNBE, 1985). This status has remained ever since. After the 1990s, the emphasis has strongly been on sustainable devel opment and the concept of biodiversity has emerged as an important bridging concept not only in biology, but also in other school subjects. Thus, currently, every school subject in primary and secondary school in Finland should contain something that can be described as EE.

Traditionally, both formal and nonformal EE have been seen as a responsibility of Finnish munici palities, and the forthcoming revised Nature Conservation Act is expected to formalize this (Finnish Ministry of Environment, 2021), which will probably strengthen the role of nonformal EE. In practical terms, several governmental and non-governmental organizations (NGOs) run EE outside the school system. A substantial number of these, such as museums, zoos or nature schools, target their activities at schools, i.e., they are out-of-classroom settings for formal education, conforming to the national core curriculum. Also, these same organizations and additional organizations take part in nonformal EE.

Additional organizations could include associations belonging to the scouting movement, youth orga nizations of nature conservation associations or other NGO

Malagasy context

Madagascar is widely renowned for its high biodiversity (Myers et al., 2000). Despite the country's biodiversity wealth, Madagascar is ranked among the poorest countries and it is predominantly rural, where people rely on a combination of subsistence farming and non-timber forest products for their livelihoods (e.g. food, fuel, shelter) (Randrianarivony et al., 2016; Ward et al., 2018). Its unique biodi versity has attracted a lot of research and international donor attention (Waeber et al., 2016), that has translated into a network of protected areas as the main conservation strategy in the country (Waeber et al., 2019). Yet, Madagascar's great share of endemic species is increasingly endangered due to anthro pogenic disturbance (Schwitzer et al., 2014; Vieilledent et al., 2018), linked to political and social instability, weak governance and corruption (Jones et al., 2019; Ralimanana et al., 2022).

International actors have also influenced Madagascar's educational agenda (Brias-Guinart et al., 2020). Since the 1970s, the Malagasy government has prioritized the integration of EE into its education and environmental policy, as a strategy to recognize the value of the country's natural heritage. Since then, Madagascar has ratified several treaties and policy plans that emphasize the role of education, communication and awareness related to the environment. To mention a few: the National Policy on Environmental Education (ME & MINESEB, 2002), the National Education Policy on the Environment and Sustainable Development (MEF, 2013), Education Sector Plan (MEN, 2017). Additionally, EE has been defined as one of the priorities of the current Ministry of Environment and Sustainable Development (Ministère de l'Environnement et du Développement durable, 2020).

Despite these policy plans, little has been implemented into practice, and environmental and social-ed ucational issues persist. As an example, a study by Heriniaina (2013) found that exotic species are better known and preferred by schoolchildren than endemic species. Overall, EE strategies within the current Malagasy school system remain weak and EE is only marginally integrated into teacher training curricula (Niens et al., 2021). In practice, most EE interventions are conducted by nonformal education organizations: mostly NGOs (both national and international) (Brias-Guinart et al., 2020), but also by churches, civil society, and associations that contribute to raising awareness in various parts of Madagascar using a variety of tools and techniques.

Methods

The study context

*I*n our study, we targeted EE practitioners to explore the purpose of EE in their organization. We focused particularly on governmental organizations and NGOs conducting nonformal EE programs throughout Madagascar and Finland. Due to the existing large differences in the status of EE in the formal school system between the two countries, we focused on nonformal education, as that gave better grounds for comparison. Additionally, nonformal organizations, as opposed to the formal school system, have more flexibility to adapt the content and teaching methods, which result in a greater diversity of perspectives and approaches that provide richer grounds for analysis.

We identified participants via snowball sampling (Browne, 2005). We conducted 31 interviews (15 in Madagascar and 16 in Finland). We included a representative sample of actors for both countries. The profile of actors conducting EE is different in the two countries (see Appendix S1). In Madagascar, they are mostly NGOs with a high number of foreign organizations. Funding is provided mainly by interna tional foundations, as well as development agencies, zoos, and private donors. In Finland, on the contrary, most organizations are Finnish, and are a patchwork of zoos, museum, churches, companies, and associations. Funding comes substantially from public sources (from municipal to national ones), and from private funds. In Finland, we focused on organizations targeting people under 18 years of age. In Madagascar, although we did not select organizations based on that criterion, most represented organizations also target children and youth.

Data collection

We conducted the data collection during September-October 2019 (Madagascar) and May-October 2020 (Finland). In most cases, the interviews were one-on-one between facilitator and participant, lasting between an hour and a half, and two hours each. We asked participants to describe the views of the organization, rather than describing their own beliefs. In Madagascar, ABG did the interviews in or French; in Finland, MH conducted them in Finnish. Throughout the research in both countries, we adhered to the standard ethical procedures of Free Prior and Informed Consent with each participant, and we followed the guidelines of the Finnish Advisory Board on Research Integrity. The research was approved by the Ministry of Environment and Sustainable Development of Madagascar (9 July 2019, 182/19/MEDD/SG/DGEF/DGRNE).

We created an interview protocol adapting the methodology detailed by LaMere et al. (2020) (for more details on the full protocol, see Brias-Guinart et al., 2022). We conducted various pilot sessions and revised the protocol accordingly to ensure clarity and relevance across backgrounds and cultures. At the beginning of each session, the facilitator explained the ToC tool to the interviewees to ensure a similar level of understanding. The facilitator used three main questions to guide the process of drawing the ToC diagram (see Figure 1): What is the intended long-term outcome of your education program? Which intermediate outcomes will lead to your ultimate goal? Which education activities or interventions is your organization conducting? These questions were reiterated as needed until reaching saturation.

In dialogue with the facilitator, interviewees drew the diagrams themselves, ensuring co-ownership and transparency of the research process (Belcher et al., 2019). In addition, this methodology provided opportunities to engage in critical reflection and examine interviewees' assumptions (Krasny, 2020), while avoiding possible social desirability bias (i.e., the tendency to give answers that make the respondent look good (Paulhus, 1991)). As a result, each ToC was formed by two elements: a diagram (Figure 1) and a narrative. The narrative was the transcription of the audio-recording during the interview to provide more detail on particular elements of the diagram.

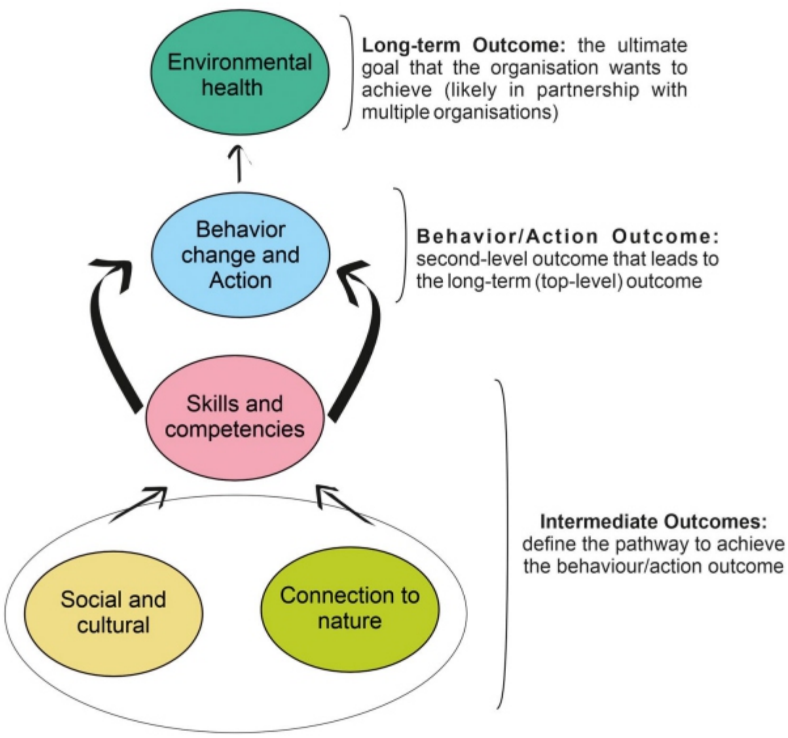

Figure 2. Interactions among the five core outcomes of environmental education (EE) (adapted from Clark et al., 2020) are represented here as a theory of change (based on Krasny 2020). This is just an abstraction of the five core outcomes, as not all EE programs focus on environmental quality as their long-term goal. For example, some may aim to increase skills and competencies as their ultimate outcome.

Table 1. Core outcomes (Adapted from Clark et al., 2020).

Core outcome	Definition
Behavior change and action	From concrete environmental actions to behavior change and lifestyle changes
Connection to nature	Importance of experience in and interaction with the biophysical environment, including emotions and positive attitudes toward nature.
Environmental health	Improve environmental health
Social and cultural aspects	Improve social and cultural aspects of the community
Skills and competencies	Psychomotor and skill-based domain of environmental literacy; includes action competence. Includes from very concrete skills like learning how to plant a tree to very general ones like learn how to manage your resources
Cognitive domain	The knowledge-based domain: include knowledge, understanding and awareness
Economic aspect	Economic aspects: from circular or green economy to alternative livelihoods
Bridging strategies	Strategies or outcomes from another field or area that can have a synergic benefit with EE goals. Include human health, access to education and literacy, EE institutionalized and law enforcement

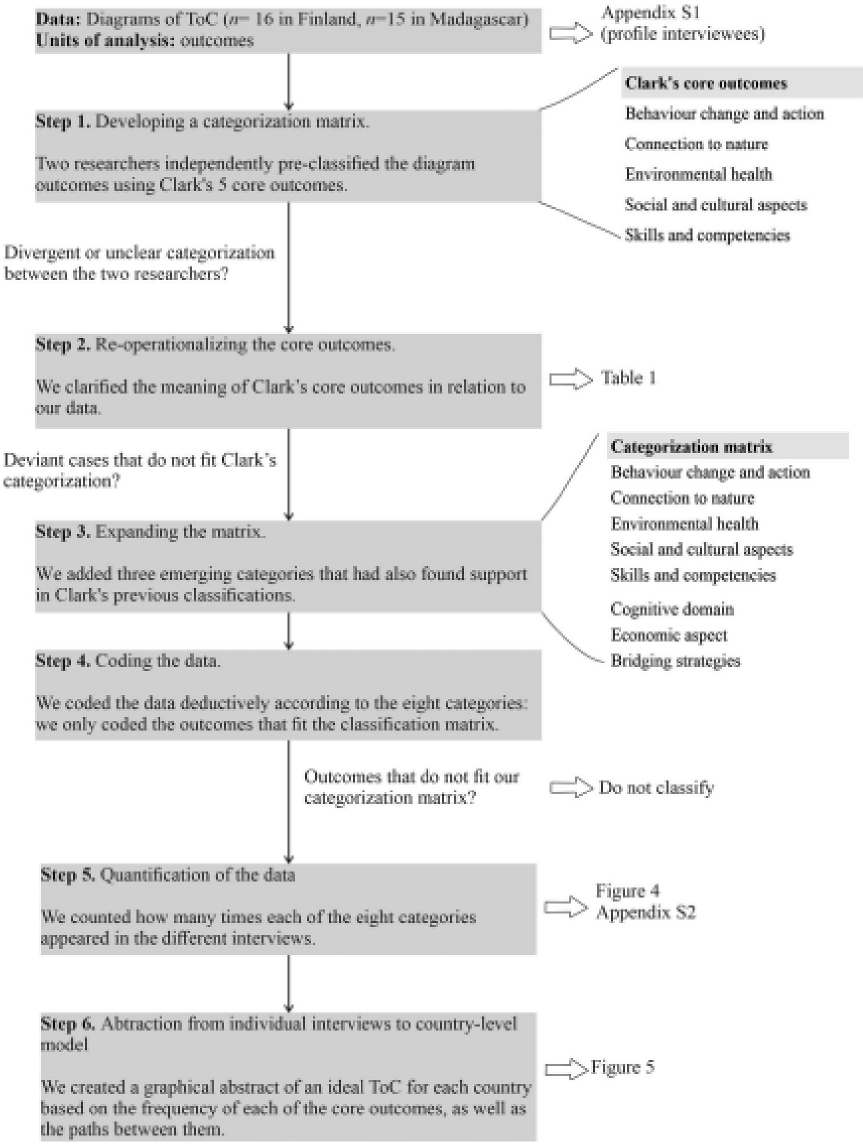

Figure 3. Methodology flow chart. The chart describes each of the steps of the data analysis, connecting them with the corresponding table and figures.

Data analysis

We were interested in identifying the goals of EE according to practitioners working in Finland and Madagascar. Our units of analysis were the outcomes as they appeared in the diagrams, supported by the transcripts of the interviews when clarifications about the written abstractions were needed and to extract quotes to illustrate the different categories. The data from the diagrams was translated into English. As explained before, the diagrams were drawn by the interviewees themselves and, for this reason, had their explicit acceptance.

We conducted a content analysis, deductively coding the diagram outcomes using Clark's conceptual framework (Figure 2). To do this, we included as our units of analysis outcomes recognized as either long-term or intermediate by the interviewees and we followed the steps described in Figure 3. We did a first round of coding using Clark's five core outcomes. After that, we expanded the categorization matrix, adding three emerging categories that had found support in Clark's previous classifications. Then, we did a second round of coding the data with the eight categories (Table 1). Each of the steps of the data analysis was done in duplicate independently by two researchers (ABG and TA). After each step, the two researchers discussed potential disagreements and decided how to proceed on the following step. Yet, we acknowledge the outcomes are intertwined and connected, rather than exclusive from one another (Braus et al., 2022).

Once the outcomes were categorized, we counted how many times each of the eight categories appeared in different interviews (Figure 4). Finally, to create a conceptual synthesis and contrast the two countries, we formed a consensus graphical abstract based on the frequency of each of the core outcomes, as well as the paths amongst them (Figure 5).

Trustworthiness

We reflect on the trustworthiness of this qualitative study by embracing some of the strategies advocated by Shenton (2004). We chose ToC as a research methodology to ensure the credibility of our sampling, and to address possible reflexivity issues. Our mix of nationalities (Malagasy, Finnish and Spanish) allowed for prior understanding of the cultural context of both Finland and Madagascar. In addition, thanks to previous visits to Madagascar, we had developed an early familiarity with some of participants. To allow transferability, we provide details on the context and boundaries of the study for the reader to decide whether the findings can be applied to another setting. At the same time, the detailed methodological description enables understanding of the methods and their effectiveness (dependability). Finally, we acknowledge the limitations of our research and that the positionality and values of the authors—trained in ecology and conservation research—had certain impacts on the data collection process and subsequent data interpretation (confirmability).

Findings

EE core outcomes for practitioners in Finland and Madagascar

We classified the outcomes mentioned by the interviewees into eight different categories as the core outcomes of EE, five of them corresponding to Clark's framework, complemented by three additional ones that we identified. While in most cases the diagrams were sufficient to code the outcomes and classify them, transcripts were used to clarify a few entries. For example, the outcome "the restoration" could be referring to a change that should happen in the community (behavior change and action) or in the environment (environmental health). After looking at the transcript, "there will be a day when the local community will be aware of the importance of the ecosystem and they will be themselves who will do the restoration of the abandoned rice fields" (Interviewee M10), we coded the outcome as behavior change. The outcomes fit under the same main categories in both countries. Yet, there were clear differ ences in content for some of the categories, as described next.

Category 1. Behavior change and action

This category ranged from concrete environmental actions (e.g., planting trees, restoring a natural hab itat), to behavior change in general or to more sustainable lifestyle.Finnish interviewees described a shift to a sustainable lifestyle:

We think of it as education for a sustainable way of life. So, these actions that we have, for example, to prevent climate change, that they would be part of everyday habits. In other words, what we strive for is that these actions, the concrete things, would be part of everyday, normal life (Interviewee F8

Malagasy interviewees frequently mentioned that their organizations target natural resource users living near to natural protected areas, and thus, the change of behavior and practices referred to users' relationships to those natural resources. As one interviewee said:

The local communities are still dependent on the natural resources, they cut the forest, collect firewood, cut the trees for the house constructions, … so we try to change their behavior, to be good citizenship like, "ok, it is not allowed to do this, and this and this" (Interviewee M12).

Category 2. Connection to nature

The outcomes classified to this category differed between Finnish and Malagasy interviewees.Finnish interviewees commonly mentioned fostering a positive relationship toward nature. Other outcomes mentioned were appreciation, care and respect of nature:

Forming some kind of relationship with nature that usually comes after spending time in nature, or some kind of remarkable experience …. That relationship adds somehow to their understanding that we are part of nature, and what pristine nature still exists in Finland (Interviewee F10).

Malagasy interviewees described more abstract relationships with nature such as love of biodiversity or animals in their natural habitat. For instance: "there [in the park visit] is only the joy of seeing the things, the animals and the natural habitat, and they [the students] are really excited…" (Interviewee M10).Nevertheless, both Finnish and Malagasy interviewees mentioned that the connection to nature appears after spending time in the forest. As one interviewee said:

I think is different because if they just go at the education center, and then we give them theory, they just imagine what they are trying to protect, but if we invite them to visit the park, they have in mind that they are protecting something real, concrete things, I think that's it (Interviewee M4).

Category 3. Environmental health

This category encompassed outcomes such as improving the status of particular species or ecosystems (e.g., lemurs, insects, forest), securing the well-being of nature in general, and reducing environmental pressures. One participant described: We have two goals: one is to increase forest cover, to recover half of what was lost, and the other one is to remove those species from critically endangered" (Interviewee M9). In Madagascar, common environmental threats were deforestation, gold mining, and poaching.

In Finland, pressing environmental concerns were the use of natural resources, climate change, food waste, and landfill waste.

Category 4. Social and cultural aspects

We included all the outcomes that referred to a benefit for the community or wider society in this category.In the Finnish interviews, it was mentioned only once as "striving for common good": We try to teach that when everyone has as much everyone else, it is good for everyone" (Interviewee F9).In the Malagasy ones, it related to improved governance of natural resources by increasing the participation of local communities in conservation actions: The local communities should be involved in the protection of the forest … For example, they should be members of the VOI [community-based natural resource management association], guides, forest patrol…" (Interviewee M12).

Category 5. Skills and competencies

We defined skills and competencies broadly. Skills ranged from social and leadership skills to action competence skills to preserve the environment, including also scientific skills and outdoors skills. In addition, many interviewees mentioned enhancing a sense of agency, as well as empowering children, youths, and local communities to become environmental agents related to the management of their own natural resources, or sustainable development in general:

One of our goals is that they [kids and other target groups] will have skills, that they are motivated and empowered to act, that they are the ones who act themselves, but also affect their local environment in their own communities, so that change happens (Interviewee F12).

In the Finnish context, this feeling of agency referred to the individual level: children and youth being able to speak out.
In Madagascar, agency was connected to empowering local communities to become future actors and leaders in biodiversity conservation.

So that in the future the EE program is fully implemented, but also that one day there is no need for our NGO anymore, and they would be teaching their own children or other children. So that they become the next generation of conservationists and rangers protecting their forest (Interviewee M2).

Category 6. Cognitive domain

Most interviewees included the cognitive domain as a core outcome. For instance, 13 out of 16 inter viewees in Finland, and 14 out of 15 in Madagascar mentioned at least one cognitive outcome as either long-term or intermediate. Thus, we decided to include the "cognitive domain" in our classi fication matrix, even if Clark et al. (2020) had defined the programs focusing on environmental knowledge as foundational (i.e. that support core outcomes). This category ranged from access to expanding knowledge and understanding (including critical thinking), to increase awareness of environmental topics. As one interviewee mentioned: "Learning is not just about acquir ing knowledge, but it is also understanding the connections, understanding the importance of insects, for example" (Interviewee M13). Some organizations focused on particular species (e.g., large car nivores, insects, lemurs), whereas others spoke generally about biodiversity, nature or the environment

Category 7. Economic aspect

We included this category in our matrix as economic outcomes were a common occurrence in Malagasy ToC diagrams. In the Malagasy context, these were linked to access to alternative livelihoods: "The local communities should have access to alternative solutions that avoid the dependence on the forest (…): for the food, for the house and for fuel" (Interviewee M12).
While rare in the Finnish interviews, it appeared related to circular economy and work-life experiences.

We train new entrepreneurs in the themes of circular economy. … The underlaying idea is that in future there is no environmental experts but every worker should be the environmental expert in their company" (Interviewee F8)

Category 8. Bridging strategies

Similarly to the previous one, outcomes related to bridging areas were one of the differentiating factors between both countries, as no Finnish interviewees mentioned outcomes in this category, but they were mentioned by more than half of the interviewees in Madagascar (see Appendix S2). We included in this category outcomes that would typically not be considered as EE outcomes (e.g. Ardoin et al., 2020)—articularly in Global North settings—but that may be seen as critical in parts of the world with high biodiversity and harsh societal conditions (Padua, 2010, Brias-Guinart et al., 2022).

Malagasy interviewees described outcomes related to human health (including family planning and hygiene practices), access to studies and literacy, law enforcement, and institutionalization of EE through government and non-governmental means. For example, related to human health, one interviewee said:

[The park] is experiencing much higher disturbance …, and one of the main reasons is that there is a much larger human population around the park. … The population growth rate in Madagascar is not sustainable currently, but more importantly, women repeatedly inform us on their difficulties in obtaining family planning services. And that is why now we have established a very active family planning program (Interviewee M8).

Another interviewee also reflected on the hygiene: "It is not just about biodiversity, but more things, so it is also included water, sanitation, and hygiene. … What we do is that we raise awareness about the use of latrine and the use of garbage pit" (Interviewee M13).

Talking about access to education, one interviewee said:

We have a program that focus specially in giving scholarships to students, so they can go to school for longer time, so they can have a job, rather than fishery, so they can escape from fishing, and they can become actors and leaders from their community to make a change in the environment (Interviewee M15).

Commenting on law enforcement, one of the interviewees said:

When people see that someone has broken the rule, but he is not punished, then they say, since there is no punish ment, why I am not doing the same thing? So that is why we are working on the law enforcement as well with the education (Interviewee M9).

One respondent commented on the institutionalization of EE:

We [our organization] try to support the civil society that works in Education for Sustainable Development to collaborate with the government to develop the curriculum that integrates the sustainability dimension. Here the youth are not direct actors, but at the end of the day, that benefits youth. If they are still at school, they will learn what sustainability is, what they need to do to protect the environment, and all that, so that can help them to become, in long-term, direct actors (Interviewee

M6).

Similarities and differences between Finland and Madagascar

We found clear indications of generalized differences between countries both in the frequency of each of the core outcomes (Figure 4), and the paths amongst them (Figure 5). Yet, some similarities appeared across the two countries as well. For individual answers for each organization, refer to Appendix S2.

In terms of long-term outcomes, behavior change and health of the environment were common in both countries. No interviewee mentioned social and cultural aspects, economic aspects and bridging strategies as long-term outcomes. Connection to nature was the most common long-term goal in Finland, whereas none of the Malagasy interviewees' long-term outcomes were classified as such (Figure 4).

In terms of intermediate outcomes, those in common for both countries were cognitive domain, connection to nature, behavior change and health of the environment. Yet, Madagascar had a greater diversity of intermediate outcomes, with outcomes in all eight categories, whereas Finland had few economic, social and cultural outcomes, and no bridging strategies. Skills and competencies was much more common as an intermediate outcome in Madagascar than in Finland.

When we articulated the core outcomes as a ToC (Figure 5), the paths amongst the outcomes become apparent. As in Clark's framework, environmental health remained the ultimate goal in both countries (Figure 5, on the top). Just below this one, behavior change and cognitive domain were long-term out comes for both countries. In the case of Finland, connection to nature was also an important long-term outcome—even more common than behavior change—whereas that remained an intermediate outcome in the case of Madagascar. On the contrary, skills and competencies were prioritized as a long-term outcome in Madagascar. In both countries, economic, and social and cultural outcomes remained as intermediate outcomes (Figure 5, on the bottom). Madagascar had one extra outcome: bridging strategies, which intersect and find synergies with all other outcomes.

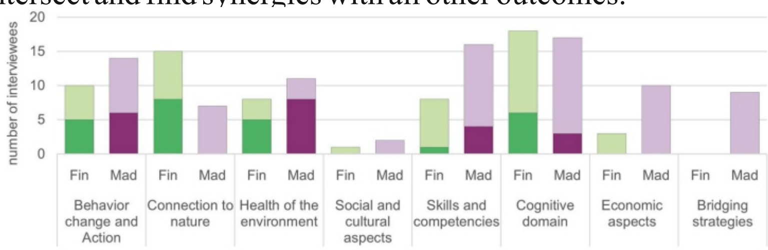

Figure 4. Bar graph illustrating the number of interviewees (y axis) that mentioned at least once the outcomes classified into each of the eight categories (x axis), differentiated between Finland (green) and Madagascar (purple) and long-term outcomes (dark color) and intermediate outcomes (light color).

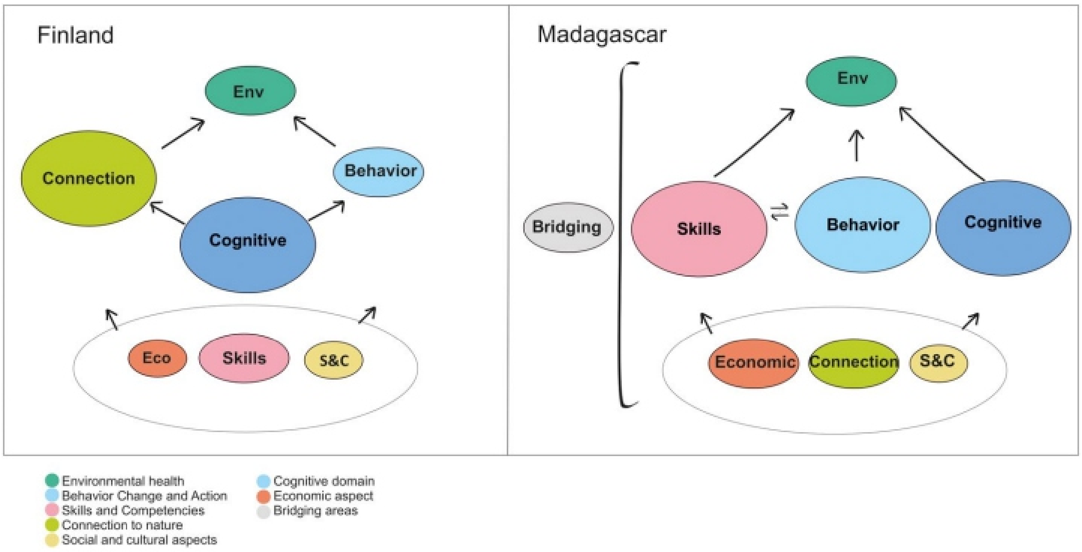

Figure 5. Core outcomes for environmental education in Finland (on the left) and Madagascar (on the right). The three different sizes of the bubbles indicate how often different interviewees mentioned that outcome (from small to big, less to more often). The top outcomes are the ones defined as long-term outcomes, whereas the bottom ones are the intermediate outcomes.

Discussion

Our research illustrates the similarities and differences in the purpose of EE amongst practitioners from a Global North and a Global South country: Finland and Madagascar. The classification of practitioners' answers from both countries mostly fit with Clark's framework on the core outcomes that focus the EE field (Figure 4). Thus, our results reflect, to some extent, a general universal pattern on the core outcomes for EE. However, when we take a closer look at our results, differences arise: even if the categories were the same between the two countries, they include a spectrum of concepts and understandings.

The two countries present a very distinct institutional landscape in terms of EE and natural resources. Yet, some commonalities emerged on the importance of core outcomes (Figure 5). We next discuss the extent to which the goals and priorities of EE reflect the different sociocultural contexts of both countries.Surprisingly, the cognitive domain was a common outcome for most of organizations in both countries, despite differences in the history and institutionalization of EE. We anticipated that the cognitive domain would be more relevant in Malagasy organizations, as those organizations fill in the gaps of the formal school system, whereas we expected that Finnish organizations would not focus as much in the cognitive domain, as that is already included in the school curriculum.

Emphasis on the cognitive outcomes may be tied to the expectation that increased knowledge and awareness will lead to environmentally responsible behavior (Price et al., 2009). Cognitive outcomes are often used as indicators of success in impact evaluations (Thomas et al., 2019) and thus, the focus on cognitive outcomes may be influenced by the requirements of accountability between organizations and funders. Donor appraisals tend to focus on tangible and easily quantifiable measures of success and failure (Ebrahim, 2002). At the same time, organizations may see cognitive outcomes as "objective mea sures" that offer the opportunity to prove to funders the effectiveness of their programs (Sherrow, 2010). This is particularly relevant in contexts where education programs are dependent on external (and often limited) sources of funding, such as the case of Madagascar (Reibelt et al., 2017). Interestingly, North American practitioners in Clark's study did not rank the cognitive domain as one of their top five outcomes. This rationale aligns with the literature that suggests that, even if knowledge is a necessary component to foster environmental literacy (Hollweg et al., 2011), it is rarely sufficient and independent to lead to behavior outcomes (Schultz, 2002).

Furthermore, the emphasis on the cognitive domain relates to an instrumental approach of EE, often associated with formal education, that focus on the transmission of scientific knowledge to change behaviors and solve environmental problems (Fraser et al., 2015) . By contrast, we anticipated that our results would rather reflect transformative learning approaches, as those are easily adopted in nonformal settings, which are commonly not limited by national curriculum policies (Reid et al., 2021). The col laboration with the formal school system may explain the contradiction. Organizations providing EE both in Finland and Madagascar commonly take part in the formal education, which focuses on cognitive aspects. For example, in Finland, pupils might go to the zoo as part of a school trip. In the case of Madagascar, even if the connection with the national curriculum is looser, organizations often work in collaboration with local teachers and public institutions, teaching lessons during or after school, inte grating their activities with the formal curriculum (Dolins et al., 2010). Accordingly, the results in Finland and Madagascar may reveal that formal school institutions may be outsourcing EE, allocating it to nonformal organizations, which design their interventions conforming to the national curriculum.

One of the differentiating factors between the two countries was the focus on economic outcomes and other bridging strategies by organizations working in Madagascar, whereas those were rarely men tioned in Finland. An explanation for this broader understanding of EE in Madagascar may be the tight connection between conservation and development. In Madagascar, EE initiatives are mostly imple mented by conservation NGOs (Brias-Guinart et al., 2020), which are constantly reshaping their initiatives responsive to project funding and shifting sociocultural dynamics (Larsen & Brockington, 2018). In this sense, the conservation agenda in Madagascar, as in other Global South countries, is strongly linked with development, and the international donor community has long provided aid in an effort to balance conservation and poverty alleviation (Waeber et al., 2016). On the one hand, this approach attempts to address the power imbalances and the mismatch between who benefits and who bears the costs of the use of natural resources, which is particularly aggravated in countries like Madagascar. On the other hand, NGOs work to counteract natural resource dependency by providing access to alternative liveli hoods, which was frequently mentioned during the interviews. Likewise, Malagasy interviewees provided a stronger emphasis on skills and competencies as one of the core outcomes of EE. In this sense, engaging in activities like reforestation programs can increase participants' professional skills, which may eventually improve their economic situation (Pohnan et al., 2015).

Another differentiating factor was connection to nature, which was much more central and frequently mentioned by Finnish practitioners than Malagasy ones. The results regarding the Finnish practitioners align with the large body of research that argues that a greater connection to nature is needed to develop environmental consciousness and intrinsic motivation to foster pro-environmental behaviors (Whitburn et al., 2020). Calls to promote direct experiences in nature as a response to anthropogenic degradation are characteristic of life in post-industrial and urbanized societies—such as Finland (Fletcher, 2017). In fact, most studies suggesting the importance of connection to nature are conducted in Western countries (Whitburn et al., 2020). So, if the concept of connection to nature is embedded in Western countries, to what extent it is relevant in a Malagasy context?

Most Malagasy people do not have the opportunity to visit natural protected areas due to financial constraints, with the exception of fieldtrips organized during university courses or by NGOs (Reibelt et al., 2017). Ironically, Madagascar's biodiversity is an international selling point and most international tourists in the country visit natural protected areas. At the same time, local communities living close to those protected areas are, according to the interviewees, commonly lacking that "connection to nature". This may be a consequence of a model of fortress conservation. Historically, the establishment of pro tected areas has failed to fully consider the needs of local communities who directly depend on natural resources for their wellbeing, and their access to natural resources has often been limited to areas outside protected areas (Vuola & Pyhälä, 2016). Despite an increasing shift toward a conservation model with shared governance in which sustainable uses are permitted (Gardner et al., 2018), the strict, centrally governed model still remains prevalent in Madagascar and in many other Southern countries. Under this colonial legacy of conservation that has led to the denial of access to nature, attempts to "reconnect" local communities to that same nature seem nature seem paradoxical.

These reflections connect with different interpretations of the value of nature. As mentioned earlier, environmental stewardship is not a universal value (Reid et al., 2021), and nature is perceived and valued in different, and often conflicting, ways (Pascual et al., 2017). Yet, most interviewed practitioners in both countries referred to “nature” as a separate entity from humans and society (Fletcher, 2017), connectedto the Western nature/culture dichotomy (Strathern, 1980). Thus, while conservation discourses often emphasize the value of biological diversity, rural Malagasy people may see the forest as being essential for their dietary requirements, their health and a resting place for their ancestors (Fritz-Vietta, Scales, 2012). Similarly, in the case of Finland, Finnish people may appreciate nature for its potential commercial forestry, or for outdoor recreation activities such as leisure hunting, skiing or spending time at a recreational home (mökki) (Rantala & Puhakka, 2020).

The scarcity of sociocultural outcomes in our results further illustrates this ecological perspective of EE. Our expectations were that social and cultural outcomes would be more prevalent, as natural resource management in both countries is strongly connected with their sociocultural heritage, for instance, the free access to and recreational use of forests in Finland (Parviainen, 2015) or the extended tradition of collection and consumption of medicinal plants in Madagascar (Randriamiharisoa et al., 2015; Razafindraibe et al., 2013). Our results are in line with previous studies that recognize the lack of an integrated socioecological approach to EE (Jenson, 2021). In addition, these findings provide support to the claims that EE requires a complex understanding of the socioecological systems (Ardoin et al., 2020), recognizing the need to engage with values, politics, and other social dimensions (Bennett et al., 2017). On these same lines, we suggest considering approaches such as place-based education that would provide opportunities for contextualized learning, being grounded in local resources, themes, and values (Velempini et al., 2018). At the same time, sense of place encompasses a holistic view of place, incorpo rating not only a biophysical perspective but also embracing psychological, sociocultural, political, and economic systems (Ardoin, 2006).

Limitations of the research

Our choices in our research approach led to some limitations in this study. Firstly, while it would be beneficial to compare similar organizations between countries, this is not likely to be possible as the operation of EE organizations varies widely between countries. Secondly, the scope of this study is limited to between-country comparisons and future studies would benefit from examining within countries differences. Thirdly, while the core curriculum in both Madagascar and Finland is highly centralized and at the national level, some of the EE organizations are local. Thus, regional differences within coun tries might partly drive the differences. Fourthly, in the case of Madagascar, most interviewees were highly educated individuals, living in the capital Antananarivo, who were accustomed to work with international collaborators and organizations. Thus, being interviewed by a non-Malagasy researcher might not be optimal for understanding the relationship between their traditional and local sensitivities, and more Western-centric views. Fifthly, we inquired about the practitioners' perceptions of the intended outcomes of their organizations, and we did not ask about effectiveness and impact, or whether their personal opinions on EE objectives differed from the organizational ones. How closely aligned practi tioners' personal opinions are to those of the organization might also differ between organizations, and how much they have an opportunity to shape EE practices and goals in their organization.

A better place for whom?

Overall, our research provides insights into the debates on why we do EE, being one of the first attempts to illustrate the perspectives of EE practitioners beyond North America. Some questions remain unan swered: while there are different perspectives across practitioners in Finland and Madagascar, are those differences culturally grounded? To what extent do they reflect different needs, different contingencies and different contexts? Environmental organizations pride themselves on using EE as a meaningful approach to make this world “a better place”. But a better place for whom?

In general, our results for both countries reflect the tradition of EE in post-industrial countries, where EE has historically focused on conservation and natural resource management issues (Padua, 2010), failing to account for the complexity and nuances of socioecological systems (Ardoin et al., 2020). Yet, the inclusion of aspects of human health and livelihoods in the Malagasy context reflects a broader understanding of EE. In addition, organizations providing nonformal education are conditioned by thestructure of the formal curriculum, which is less flexible in terms of scope and approaches, and strongly focused on the cognitive domain. In the case of Madagascar, EE is influenced by funders, Western epis temologies on nature/people relationships, international development goals, and a colonial legacy of biodiversity conservation, rather than local cultural contexts. Nevertheless, our results also support alternatives to the instrumental tradition of EE: some interviewees mentioned skills to empower youths and adults to become environmental agents for the management of their own natural resources, and improved governance of natural resources as one of their social and cultural outcomes. This perspective aligns with an emancipatory role of EE that focuses on empowering communities, and enhancing sense of agency and emancipation (Sauve, 2005; Wals et al., 2008). Moreover, it connects with the concept of justice as a key component of EE's identity (Rodrigues & Lowan-Trudeau, 2021).

The outcomes of our study further question the idea of a universal agenda for education and add to the recognized need for decolonization of EE programs (McLean, 2013; Root, 2010; Velempini et al., 2018). Similarly, our findings encourage educators to question the uncritical or decontextualized use of EE tools and frameworks and, instead, endeavor to establish programs that are environmentally and culturally appro priate (Monroe & Krasny, 2016). Therefore, differing from Clark et al. (2020) who considered the diversity of views of EE to be a roadblock, we embrace diversity of EE as a richness—and almost as a need. In line with others, we claim that successful EE interventions –both in the Global North and South—should be embedded in the people and their environment, and must be grounded in the sociocultural context, rec ognizing and working with place-based values and local understandings of natural resource use.

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Authors contributions

Conceptualization, ABG, TA and MC; Methodology, ABG; Validation, ABG, TA, MH and RH; Formal Analysis, ABG and TA.; Investigation, ABG and MH; Data Curation, AB-G; Writing—Original Draft Preparation, ABG; Writing—Review & Editing, ABG, TA, MH, RH and MC; Visualization, ABG.; Supervision, MC; Project Administration, ABG.

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Stockholm +50, Tbilisi +45, Rio +30: Research, praxis, and policy

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The year 2022 commemorates three milestones in the history of environmental protection and education: It marks the 50th anniversary of the United Nations Conference on the Human Environment, organized in Stockholm in 1972; the 45th anniversary of the first Intergovernmental Conference on Environmental Education, held in Tbilisi in 1977; and the 30th anniversary of the United Nations Conference on Environment and Development, which took place in Rio de Janeiro in 1992. Each one of these meetings influenced the field of environmental education (EE) in the ensuing decades, and echoes of these meetings reverberate until the present.

A bird's-eye view of landmark conferences

Whereas the Tbilisi conference was the first worldwide conference that addressed EE in all its forms—formal, non-formal, and informal—the 1972 Stockholm Conference set the initial impetus for its establishment among all nations, particularly Principle 19 and Recommendation 95. Principle 19 of the Stockholm Conference stated:

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. 4

Principle 19 was followed by a specific plan of action, particularly Recommendation 95, which pro posed teacher training in the field of EE, the elaboration and testing of new curricula, and pedagogical methods for all levels of EE (United Nations, 1973).

Five years later, during the Tbilisi Conference, representatives from 68 different countries put forth a set of principles and guidelines for EE at all levels—local, national, regional, and international—and for all age groups both inside and outside the formal school system. With this, two important things happened: Firstly, Tbilisi assured a narrative and discursive continuity to Stockholm in a historical context where social movements were flourishing, including the environmental movement; secondly, following the highly relevant conceptual work that came out of the Stockholm Conference, the representatives in Tbilisi set the bedrock for developing, implementing, and enacting EE concepts, policy and practice. According to the Tbilisi Declaration (UNESCO, 1977), the goals of EE were:

(a) to foster clear awareness of, and concern about, economic, social, political and ecological inter dependence in urban and rural areas;
(b) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;
(c) to create new patterns of behavior of individuals, groups and society as a whole toward the environment.

Twenty years after Stockholm and 15 after Tbilisi, the Rio 1992 Conference harbored hopes and expectations with the presence of 172 countries, with more than 100 of them represented by their leaders. Rio 1992 culminated with a non-binding action plan, Agenda 21, which mentioned education throughout its 40 chapters, but one of them in particular was entirely devoted to promoting education, public awareness, and training, with a strong focus on sustainable development. Chapter 36 called for:

universal access to basic education, and to achieve primary education for at least 80 per cent of girls and 80 per cent of boys of primary school age through formal schooling or non-formal education and to reduce the adult illiteracy rate to at least half of its 1990 level. Efforts should focus on reducing the high illiteracy levels and redressing the lack of basic education among women and should bring their literacy levels into line with those of men. (United Nations, 1992)

Notably, there have historically been strong criticisms of the shift from 'environmental' to 'sustain ability' consolidated in the Rio 92 conference, following the 1987 Brundtland report, or Our Common Future, especially in educational settings. At the core of the critique is the focus of sustainability on economic growth, alongside the commodification of human relations and of nature; as much as economic growth does have a role in just environmental development, the (historically anchored) critical sense is that the profits mostly go to the local elites and first world business and government interests, an espe cially problematic structure and dynamic in the poor parts of the world. Curiously enough, this is the case in Brazil where the Rio 92 Conference was held, and where the 'environmental' field and discourse (education; policy; research; etc.) is vastly more developed than 'sustainability' or 'sustainable development.'

Another notable issue in the Rio 92 Conference was how the approach of specifying quantifiable, measurable objectives differed from previous declarations, certainly that of Tbilisi, but inevitably David Orr's admonition comes to mind, regarding the importance of opening up the black box of education: "The conventional wisdom holds that all education is good, and the more of it one has, the better. The truth is that without significant precautions, education can equip people merely to be more effective vandals of the earth" (Orr, 1994, p. 6).

More closely tied to education itself was the 1997 Tessaloniki Declaration, which sought to celebrate 20 years of Tbilisi and revisit its original commitments. In many ways, the Tessaloniki Declaration was still riding on the coattails of Rio 1992, and as such the concept of sustainable development greatly influenced the final declaration, so much so that the Tessaloniki Declaration was notorious for not men tioning EE. To be precise, EE was mentioned only twice, and one of those instances was the suggestion to replace the concept of EE for education for environment and sustainability (Knapp, 2000, p. 33). This was reflective of two parallel phenomena: (1) The rise of the sustainable development discourse that had become increasingly influential in educational policy circles worldwide; and (2) surveys at the time that showed the vast majority of teachers spent a minimum amount of time teaching about environmental issues (e.g., in the US, in the mid-1990s, the World Wildlife Fund estimated that 86% of teachers spent 1hour or less on the environment each week, 1994).

Starting in 2000, other landmark multilateral conferences, summits, and declarations have taken place (e.g., the United Nations Millennium Development Goals of 2000; the Johannesburg Declaration of 2002; the United Nations Conference on Sustainable Development, or Rio + 20; and the Sustainable Development Goals of 2015). Given the current malaise of the planet, both socially and environmentally, alongside the large number of international meetings and pronouncements of the last 50years, it is quite easy to become cynical and bitter regarding how worthwhile they are. Eco-pessimism, environmental existential anxiety, and a profound sense of paralysis may, and have, enveloped certain groups worldwide. Nonetheless, it is vital to ask what role does environmental and sustainability research, praxis, and policy play in identifying the possibilities, breakthroughs, silences, absences, and limits of the various summits and declarations in the context of education.

Connecting educational research, praxis, and policy to landmark conferences

A cursory look at newspapers around the world show how dreadful the state of the environment is today, which may lead to a sense of hopelessness for the planet's future. While it is important to be realistic of the immense and varied challenges faced by the planet, EE by its very nature ought to offer a sense of hope and enjoyment precisely because the field seeks solutions to these difficult-to-solve problems. At JEE we suggest the embracement of a life-affirming educational philosophy that replaces fear, dread, and fatalism with courage, joy, justice, and empowerment. Below are a series of questions that offer a partial road map that could assist EE scholars in engaging in this life-affirming philosophy:

• To what extent is EE praxical, or just academic performative abstract theoretical textualism? (e.g., JEE 51(2), Rodrigues, 2020). How do we effectively close/bridge the gap between policy and action? What are some of the fundamental (preferably, simple) questions for a 'practical theory' of environmental justice? (e.g., JEE 52(5), Rodrigues & Lowan-Trudeau, 2021, asking "What is in it for Nature?"). One obvious point of departure is an exploration of the United Nations Framework Convention on Climate Change (a treaty that came into force in 1994), with organized annually through the COPs. At the COP26 of 2021, and for the first time, of Education and the Environment got together to pledge to integrate climate change into formal and non-formal education (UNESCO, 2021). Research can play a vital role in identifying strengths and weaknesses of this approach.

• Relatedly, how can we best integrate the concept of justice in international education when poorer nations that have contributed negligible amounts to fossil fuel emissions nonetheless suffer the brunt of climate change consequences? In 2022, Pakistan experienced its worst floods in recorded history: Two-thirds of the country's districts have been damaged, at least 1,200 people died, and 33 million people were displaced (Mallapaty, 2022). Can educational and economic research, praxis, and policy intersect to ensure, for instance, more intense afforestation along the Indus River? After all, the historic floods in Pakistan in 2010 were a harbinger of what eventually became a reality 12 years later. Are the collective actions that respond to environmental issues (aesthetically-ethically politically) aligned with the principles of justice historically claimed within social movements?

• How to connect the enactment of environmental laws and environmental politics with the field of education? For instance, one of the most exciting happenings in environmental law in the 21st century are the "rights of nature" provisions that confer legal rights to rivers, mountains, forests, and other ecosystems. Until recently, these rights were mostly symbolic, but in 2022 Ecuador's High Court determined that the entity responsible for a project (i.e., a corporation or the State) must demonstrate that its activity is not harming fragile ecosystems or endangered species (Surma, 2022). Identifying the role that educational research can play in supporting and exploring rights of nature laws is vital.

• Sustainability discourses continue to prioritize the economy over social and environmental concerns. In EE/EER, where, why, and when are such representations allowed to persist? 'New', 'post' (qualitative) theories seem to be dead ends, unless a decentering ecocentrism and praxis gets some performative traction within those abstractions (e.g., JEE SI 51(2), 2020). Theories that ought to play a much larger role in today's debates—such as buen vivir, degrowth, and ecological swaraj (Kothari et al., 2014)—tend to be ignored or are placed at the margins of economistic policy debates, and even more so in educational circles.

• What research evidence do we have, and where can it be found (in different geo-epistemologies), that can be used to defend experiential learning and education in the interdisciplinary framings of EE (or outdoor education, health education, sustainability education, etc.)? The pressures of capitalism in higher education are such that scholars are often forced to publish short-term empirical studies that advance little the field of EE (for an analysis of "academic capitalism," see Slaughter & Rhoades, 2009). Academic journals often receive short-term empirical studies that last between one weekend to a couple of months, but seldom do they receive articles that last one year or longer to truly assess the longitudinal effects of experiential education in all its forms, and what can be done to improve it. One article that bucked the trend was Tal and Morag's (2013) 8 year-long study of an elementary school EE program in Israel. While not all studies can last this long, the results from this and other longitudinal studies tend to be of such significance that they are well worth the effort and time.

• Do we have solid, empirically based examples where the agency of the non-human changed EE and EER? Are there potential ecopedagogical drives in social change brought forth by non-human agencies? One positive result from these conferences was the Convention of Biological Diversity of 1993. Given the continuous loss of species worldwide, one could focus on actual or potential success stories and how education played—or could play—an important role. In 2022, India reintroduced the cheetah, 50 years after becoming extinct in that country (Biswas, 2022). This reintroduction represents the first time a large carnivore is being moved from one continent to another and being reintroduced in the wild. It is too early to determine how successful this rein troduction will be, but it is clear that a parallel education campaign to teach regional populations of the importance of this effort, in addition to strong accountability and law enforcement, is vital to ensure its success.

Amnesia and silences…

In JEE's 2020 special issue on global politics of knowledge production in EER: 'New' theory and North South representations (Rodrigues, 2020), Phillip Payne critiqued the "amnesia of the moment" in EE (research) highlighting how founding policies of EE and its implied pedagogical praxis and commensu rable methodological development in EE research have given place to an ahistorical and atheoretical mash of performatively-driven abstract theorizing (Payne, 2020). The questions and examples presented in this editorial paper are aimed as a provocative call which we hope will be heeded by fellow EE research ers and practitioners: We need more memory and retrospective empirical studies in EE research about the core of EE—How does the field praxically respond to the recommendations, principles, and policies from half a century of landmark conferences? In the narrative continuity of each of these landmarks, what changed, what was reenforced (and possibly re-worded), what were/are the remaining silences?

While we are at it, why not extend the call to organizations such as the NAAEE, forums like the WEEC, and journals like JEE? How have they historically dealt with policy-action gaps and contradictions? If we do acknowledge the tendency to an "amnesia of the moment," are these organizations, forums, and scientific publication streams part of the problem of mainstreaming EE and EE research inaction against the promise and potential of Tbilisi? Or can they be part of the solution as critical histories of EE and EE research, including and beyond UN gatherings?

Following this editorial paper, the readers of JEE will find Phillip Payne's Tbilisi's "sounds of silence" - (in)action in the policy≠embodiments of environmental education as a critical response to our call. Our hope is that Payne's article will be the first of many responses, and that the collective memory-work of how different organizations (be it through events, documents, publications, etc.), past and present, address or not policy-action, or theory-practice gaps, to serve as guidance and inspiration to a more praxical EE.

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Understanding and responding to challenges students face when engaging in carbon cycle pool-and-flux reasoning

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A B S T R A C T

Carbon cycle pool-and-flux reasoning is a critical facet of climate literacy. This article begins with discussion of why this type of reasoning is both challenging and important. Results from two studies are reported. The first describes students' approaches to carbon cycle pool-and-flux reasoning. The second describes and reports results from an instructional intervention designed to scaffold secondary students' model-based pool-and-flux reasoning. Before instruction, most second ary students employed informal reasoning approaches including good versus bad and correlation heuristics to carbon cycle pool-and-flux problems. After instruction, the portion of students employing goal model-based pool-and-flux reasoning increased from 27 to 52 percent. This study builds on previous and current research to offer a promising instructional approach to scaffolding improvements in students' model-based pool-and-flux reasoning.

KEYWORDS:carbon cycle curriculum; carbon cycle pool-and-flux reasoning; climate literacy

Introduction

As environmental educators well know, climate change is one of the most urgent socioenvironmental problems facing society today. Environmental education's focus on this problem in North America is evident in the North American Association for Environmental Education's Guidelines for Excellence: K-12 Environmental Education (North American Association for Environmental Education (NAAEE), 2019). For example, middle school guideline 2.1.A indicates learners should be able to, "…provide an evi dence-based explanation of how humans have changed Earth's atmospheric gases during the last two centuries and the consequences of those changes" (NAAEE, 2019, p. 47). The Guidelines also identify "systems and systems thinking" as the first essential underpinning of environmental education, noting that, "[s]ystems thinking helps make sense of a large and complex world" (NAAEE, 2019, p. 12).

Earth's complex and changing climate is a prime context in which systems thinking can help people make sense of and respond to a socioenvironmental issue. The affordances of systems thinking are also evident in other expectations in the Guidelines. For example, high school guideline 3.1.C suggests indi viduals should be able to, “[c]ritique proposed solutions using gauges such as likely impacts on society or the environment, and likely effectiveness of solving the issue” (NAAEE, 2019, p. 81). In order to achieve this goal, students need to access and use climate system thinking (e.g., by evaluating explanations, predictions, and arguments that draw on understanding of invisible dynamic processes in the system that unfold across different spatial and temporal scales) (Hmelo-Silver et al., 2007; Hogan & Weathers, 2003).

Growing acknowledgment of the importance of climate and climate change is also evident in recent shifts in science education standards in the United States. While climate change and global carbon cycling were largely absent from the National Science Education Standards released in 1996 (National Research Council), they are prominent in the more recent Next Generation Science Standards (NGSS) (NGSS Lead States, 2013). Relevant performance expectations, for example, address: clarifying evidence of factors that have led to a rise in global temperatures (MS-ESS3-5), developing a quantitative model to describe global carbon cycling (HS-ESS2-6), and using evidence from climate models to forecast climate change (HS-ESS3-5).

This paper focuses on one key element in students' understanding of global climate change, namely carbon cycle pool-and-flux reasoning. The NGSS call on students in the United States to “[d]evelop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere” (NGSS Lead States, 2013, HS-ESS2-6). This is a particularly challenging standard to achieve because, as we will explain, most people make sense of carbon cycle data in problematic ways that lead to the erroneous conclusion that addressing anthropogenic climate change will be much easier to accomplish than it actually will be.

We do not suggest that teaching students pool-and-flux reasoning addresses all elements of environ mental education associated with goals such as environmental literacy, environmentally responsible behavior, or action competence (e.g., Bishop & Scott, 1998; Coyle, 2005; Hsu, 2004; Kollmuss & Agyeman, 2002; McBeth & Volk, 2009; Mogensen & Schnack, 2010). Understanding pool-and-flux reasoning may not directly impact peoples' climate-relevant personal and societal decisions or behaviors. However, we argue that carbon cycle pool-and-flux reasoning represents a “necessary but not sufficient” accomplish ment for informed participation in societal decision-making related to climate change.

This argument is consistent with perspectives in environmental education. For example, in various models and approaches to environmental education, knowledge is a consistently included construct (e.g., Bishop & Scott, 1998; Coyle, 2005; Hsu, 2004; Kollmuss & Agyeman, 2002; McBeth & Volk, 2009; Mogensen & Schnack, 2010). And, while carbon cycle pool-and-flux reasoning represents an aspect of knowledge necessary for environmental literacy, it is much more than just a fact to be learned. Rather, this type of reasoning involves employing sophisticated sense making to coordinate longitudinal, global scale data with a model-based, mechanistic understanding of Earth's complex carbon cycling system. Because the potential effectiveness of different climate actions is commonly evaluated based on predicted impacts on atmospheric carbon levels, carbon cycle pool-and-flux reasoning is essential for informed engagement with responses to climate change.

In the context of climate change, NAAEE's guideline 3.1.C involves critiquing the likely impacts of different goals for emissions reductions on atmospheric carbon dioxide concentrations, subsequently impact global temperatures and other climate indicators (IPCC, 2018). People who are able to use carbon cycle pool-and-flux reasoning may not make decisions consistent with sup porting effective means of addressing global climate change, but those without access to carbon cycle pool-and-flux reasoning cannot; they lack the capacity to understand the likely effects of different choices, and thus to make evidence-informed decisions about personal and policy-related climate issues. This is particularly concerning in today's society in which people have reason to be skeptical about arguments from various sources concerning socioenvironmental issues and solutions (Barzilai & Chinn, 2020; Feinstein & Waddington, 2020; Iyengar & Massey, 2019; Stubenvoll & Marquart, 2019).

Further, while human understanding of climate science and arguments concerning responses to climate change continue to change over time, some basic ideas and models (including but not limited to carbon cycle pool-and-flux reasoning) represent fundamental aspects of preparation for future learning in this domain that will remain useful over time. After they complete their schooling, individuals need to be able to continue to learn about socioenvironmental issues (e.g., through reading news articles in the media) as both the circumstances of and our understanding of those issues change (Bransford & Schwartz, 1999; Zeidler et al., 2009; Zeidler & Kahn, 2014).

Preparation for future learning does not mean knowing everything - it means being able to judge and make sense of arguments about changing and emerging issues as need arises. Pool-and-flux reasoning positions people to critique alternative goals and strategies for emissions reductions now and in the future as aspects of our global socioenvironmental system such as levels of atmospheric carbon dioxide (Co2); rates of emissions; available technologies and understandings of how they work; and circumstances of social, political, economic, and justice contexts change over time. Thus pool-and-flux reasoning is one essential, flexible facet of systems thinking that individuals need in order to be prepared for current and future participation as informed environmental decision-makers.

In this paper, we draw on research in the literature and our own design-based research to discuss (1) why carbon cycle pool-and-flux reasoning is crucial to addressing climate change, (2) why this type of reasoning is so challenging, (3) the more and less sophisticated ways middle and high school students reason about global carbon pools and fluxes, and (4) a promising instructional approach to improving secondary students' carbon cycle pool-and-flux reasoning. The evidence we present concerning students' ways of thinking and the beneficial effects of an instructional experience both draw from a large-scale design-based research project aimed at teaching students to trace matter through carbon transforming processes at multiple scales from atomic-molecular to global (Anderson et al., 2018; Cobb et al., 2003).

Why quantitative carbon cycle pool-and-flux reasoning is critical for addressing climate change

Figure 1 presents an iconic image that is frequently used as evidence that CO2 concentrations in the atmosphere are increasing. Known as the Keeling Curve, it documents the increasing concentration of CO2 in the atmosphere at Mauna Loa, Hawaii between 1958 and the present. Most students we have interviewed or who have completed written assessments for our project believe that increasing Co2concentrations are bad and that we should do something about them. The questions of what to do and how much difference it will make, however, are more complicated.

Most students correctly attribute the upward trend in the Keeling Curve to human activities that use fossil fuels. On the surface, this connection seems straightforward. For example, one can compare time series graphs showing the Keeling Curve and the fossil fuel flux of carbon into the atmosphere (Figure 2). Eyeballing the trends in these graphs, they look similar. If we look at the period from 1958 through 2010, we see that in both cases, trends are going up steeply over time. This leads to a seemingly logical conclusion: If we can reduce CO2 emissions (i.e., get the lines in Figure 2 to start going down), then CO2 concentration (the line in Figure 1) will start going down too. Unfortunately, the relationship between CO2 emissions and CO2 concentration is not that simple. Figure 3 shows why.

Global carbon cycling involves the multiple processes (photosynthesis, cellular respiration, com bustion, etc.) that move carbon among connected pools in the geosphere, hydrosphere, atmosphere, and biosphere. When these systems have balanced carbon fluxes, the sizes of carbon pools remain the same over time. When fluxes are imbalanced, pool sizes change over time. What's more, it only takes a small imbalance in fluxes to make a large change in a pool's size over time. Figure 3 shows that the flux from burning fossil fuels (10 GtC/year) is far smaller than most other fluxes into and out of the atmosphere, but it is unbalanced. We can calculate the overall carbon flux using the Figure 3 model by summing the annual fluxes into the atmosphere (208 GtC/year), summing the fluxes out of the atmosphere (200 GtC/year), and comparing the two; this yields a net flux of 8 GtC/year into the atmosphere.

Pool-and-flux reasoning shows us that simply reducing emissions will not reduce or even stabilize the atmospheric carbon pool. With reduced emissions, the atmospheric CO2 concentration will continue to grow at a slower rate. This is the crux of why pool-and-flux reasoning is so important. Stabilizing the concentration of CO2 in the atmosphere will require not just reducing emissions, but reducing them to an extent that will sustain the global carbon cycling system at or near a balanced-flux state indefinitely (i.e., fossil fuel emissions will need to be close to zero or else other actions will need to be taken to move more CO2 from the atmosphere back to terrestrial and ocean systems to balance the fossil fuel flux into the atmosphere).This is why the NGSS emphasize quantitative modeling of global carbon cycling as a key goal. Students (and people in general) need to recognize the actual problem we are facing with respect to addressing climate change in order to make informed decisions concerning the changes that are required to avert the most catastrophic projections for climate change. In the next section, we discuss research from related fields that explains why people, spanning from middle school students through science experts, have so much trouble with pool-and-flux reasoning.

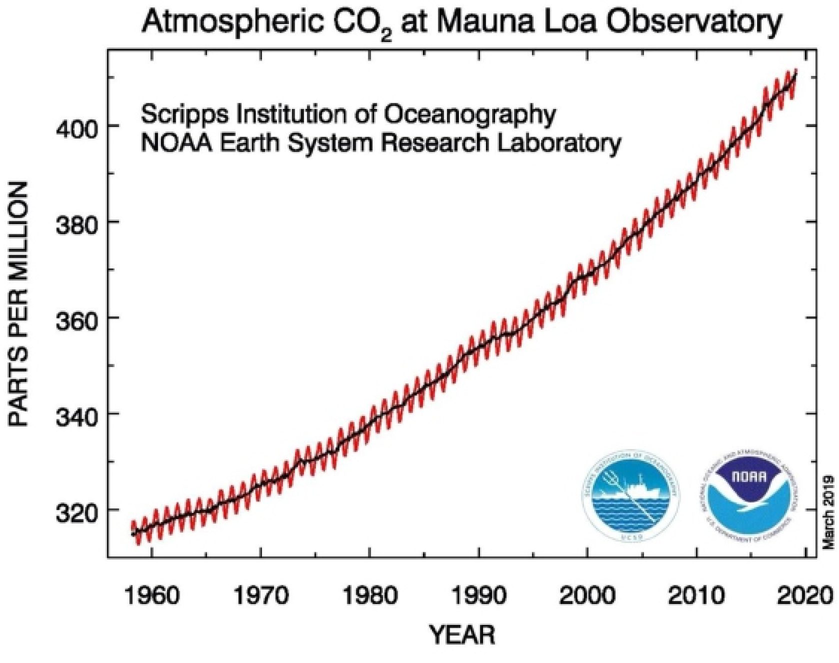

Figure 1. Keeling Curve (record of atmospheric CO_2 concentration at Mauna Loa) (National Oceanic & Atmospheric Administration, 2019).

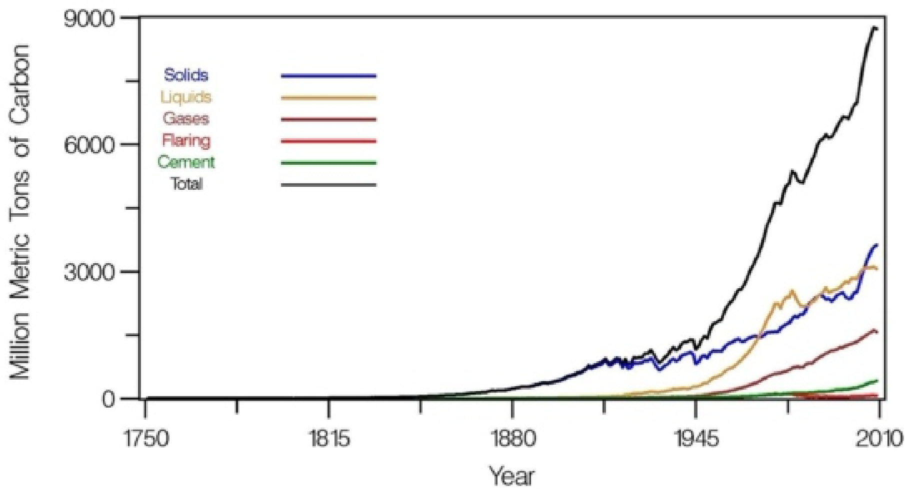

Figure 2. Global fossil fuel carbon emissions (Boden et al., 2015).

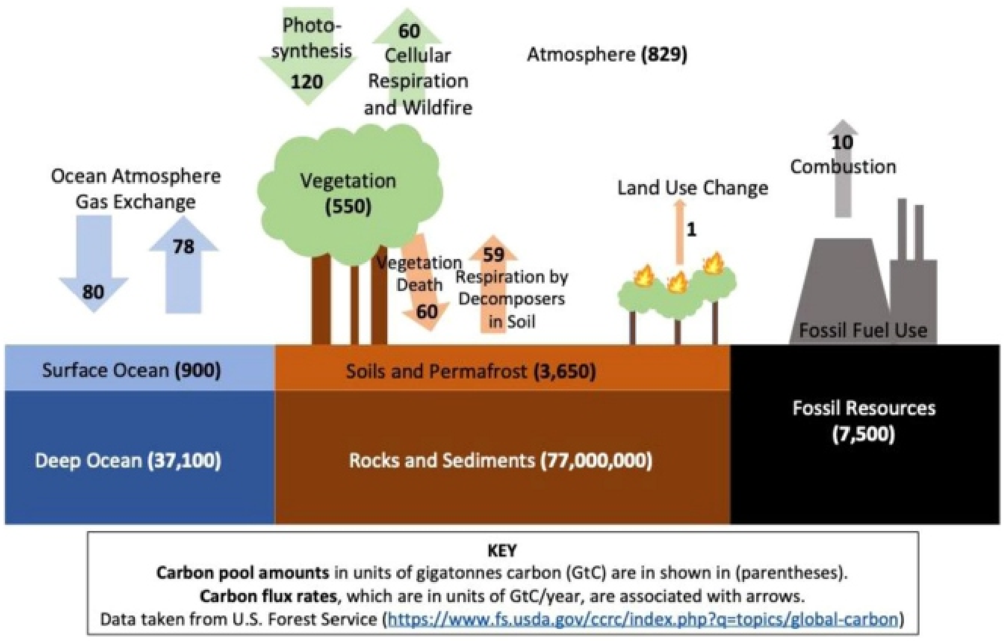

Figure 3. Global carbon cycle model.

The challenge of carbon cycle pool-and-flux reasoning

Studies of pool-and-flux reasoning in different contexts

Studies conducted over the past several decades provide an illustration of the kinds of trouble people encounter when they reason about pool-and-flux problems. This research has been conducted with a variety of participants, though often with university undergraduate and graduate students. The work has been conducted using a range of pool-and-flux problems including water in a bathtub, oil in a tank, people in a building, air in a balloon, dollars of national debt, distance between cars, and CO2 in the atmosphere (Cronin et al., 2009; Dutt & Gonzalez, 2012; Guy et al., 2013; Moxnes & Saysel, 2009; Reichert et al., 2014, 2015; Sterman & Sweeney, 2007).

Findings have been consistent. People, including those with technological expertise and training, are generally poor pool-and-flux reasoners. Instead of recognizing fluxes as rates of change and pools as amounts of materials, people often oversimplify these problems and view fluxes and pools as having a simple linear relationship. This tendency has been labeled both "correlation heuristic" and "pattern matching" (Cronin et al., 2009; Dutt & Gonzalez, 2012; Moxnes & Saysel, 2009; Sterman & Sweeney, 2007). Basically, when dealing with pool-and-flux problems, individuals will often assume that if a flux has a positive trend then a pool will have a positive trend, and vice versa. As noted by systems scientists, this simplifying heuristic can lead individuals to grossly underestimate how much we will have to reduce CO2 emissions to stabilize or reduce the atmospheric carbon pool (Sterman & Sweeney, 2007).

Other studies provide evidence of additional informal reasoning approaches, aside from the correlation heuristic. For example, Sweeney and Sterman (2007) found that middle school students sometimes consider inflow but not outflow in pool-and-flux problems. Niebert and Gropengiesser (2013) analyzed metaphors that scientists and high school students use to understand climate change; they found that students viewed anthropogenic CO2 as "bad" because it is made by people rather than being natural. Similarly, in our research (Covitt & Anderson, 2018), we have found that high school students often use informal approaches to making judgments and predictions about phenomena related to climate and climate change. These include, for example, covering law approaches (Braaten & Windschitl, 2011), which describe things such as pollution and climate change just going together without explaining underlying mechanisms and qualifications (e.g., how does pollution impact climate, which types of pollutants, from which sources, and to what extent). We have also observed fast thinking heuristics (Kahneman, 2011) such as eyeballing graphs and simply extending patterns and trends in graphs to make predictions for future CO2 levels.

Informal approaches to judgments served our prehistoric ancestors well and have become prevalent among the human population (Gigerenzer & Todd, 1999; Payne et al., 1993). In many quotidian contexts, quick and decisive approaches to making judgments are desirable (Kahneman, 2011). Without quick thinking, people would get bogged down in every little decision (e.g., what should I have for breakfast today?) and find it difficult to complete larger and more significant tasks. In most of our everyday expe riences and contexts, the correlation heuristic is an effective approach. Sterman and Sweeney (2007) provide a few examples such as kettle whistling correlates with water boiling, and eating certain mushrooms correlates with becoming ill. Unfortunately, quick thinking approaches like the correlation heuristic are insufficient for the task of making informed critiques of proposed solutions to climate change.

Studies of instructional interventions focusing on pool-and-flux reasoning

Van Dooren et al. (2007) found that oversimplified correlational or linear reasoning was highly prevalent among sixth graders, and that it was reinforced by the common use of word problems in school that prompt students to identify linear relationships. Van Dooren and colleagues also found that interventions that required students to go beyond verbal and text writing performances (e.g., to undertake drawing or manipulating objects) helped students to avoid misapplied linear reasoning. However, on a subsequent posttest, students in all conditions returned to linear reasoning strategies. The interventions helped disrupt linear reasoning about a particular example but did not change students' overall tendency to apply linear reasoning.

As with Van Dooren and colleagues' (2007) interventions seeking to disrupt linear reasoning, attempts to help individuals achieve more sophisticated pool-and-flux reasoning have shown that some approaches can have significant impacts, but also that students often revert to applying the correlation heuristic. Some approaches that have been shown to at least modestly improve pool-and-flux reasoning include providing feedback (Cronin et al., 2009), interacting with pool-and-flux simulations (Dutt & Gonzalez, 2012), employing analogies (Guy et al., 2013; Moxnes & Saysel, 2009; Reichert et al., 2015), introducing a cognitive conflict (Moxnes & Saysel, 2009; Reichert et al., 2015), and employing cognitive flexibility principles (Reichert et al., 2015). Other approaches have demonstrated mixed results. For example, Guy et al. (2013) found that employing graphs in problems can lead to relatively worse reasoning outcomes. Cronin and colleagues (2009), however, found that employing graphs did not negatively influence rea soning. Approaches including simplifying problems and providing motivational incentives have also been shown to be ineffective in some experiments (Cronin et al., 2009).

Studies of instruction about climate change

To date, few studies have examined or documented changes in pool-and-flux reasoning among secondary students as a result of learning experiences. Thus, little evidence has been presented to suggest that secondary students can learn to successfully use pool-and-flux reasoning, especially in the context of the carbon cycle. A search of both research and practice literature suggested that much of the work at the secondary level has focused on either describing students' understanding of climate change without examining learning (e.g., Chang & Pascua, 2016; Düsing et al., 2019; Özdem et al., 2014; Shepardson et al., 2009, 2011, 2014; You et al., 2018) or describing climate change and/or carbon cycle instruction without addressing or examining learning related to pool-and-flux reasoning (e.g., Bofferding & Kloser, 2015; Pruneau et al., 2003).

Some curricular materials we found in the literature focused on the pathways carbon moves through without requiring students to engage in quantitative pool-and-flux reasoning, which is required for making sense of changes in pool sizes over time (e.g., Hoover, 2019; Peel et al., 2017). One study examined secondary students' reasoning relevant to pools and fluxes using a qualitative approach that provided useful insights but did not provide a more generalizable examination of whether and how educational experiences might support significant learning in this domain among secondary students (Niebert & Gropengiesser, 2013). Another study found only 20% of students achieved qualitative model-based carbon cycle reasoning as a result of instruction (pool-and-flux reasoning was not explicitly addressed in the study) (Zangori et al., 2017). In summary, research to date has not produced evidence of or from effective approaches for scaffolding secondary students' learning of carbon cycle pool-and-flux reasoning.

One other issue to note with regard to educational implications is that carbon cycling is a particularly complex pool-and-flux reasoning problem when compared with many other examples (e.g., pools of national debt and fluxes of revenue and spending, pools of money in a savings account and fluxes of deposits and withdrawals, pools of water in a bathtub and fluxes of water entering and exiting). While the carbon cycle comprises multiple pools and fluxes moving carbon through a complex system, in all the examples above, there is only one pool and two fluxes (one in and one out).

Summary

Past research on pool-and-flux reasoning surfaces several key points. First, pool-and-flux reasoning has been recognized as an important learning target in several different fields. Second, difficulty with this type of reasoning tends to arise when people rely on simplified heuristics that produce quick but sometimes inaccurate conclusions. Third, teaching students when and how to use pool-and-flux reasoning is hard. And finally, research on teaching climate change has generally not recognized the important role of pool-and-flux reasoning or documented successful strategies for teaching it.

Background and research questions

Learning progressions and design research

The two studies reported in this article represent work situated in learning progressions theory (Duncan & Rivet, 2013) and the methodological approach of design-based research (Cobb et al., 2003; Collins et al., 2004). These theoretical and methodological lenses are leveraged to examine and respond to the educational challenge of teaching pool-and-flux reasoning with secondary students.

"Learning progressions are descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn about and investigate a topic over a broad span of time" (National Research Council, 2007, p. 214). Development of empirically grounded learning progressions has been shown to hold promise for advancing and informing multiple aspects of research-based education efforts including in areas of formative assessment, measurement of student learning, creation of responsive curriculum materials, and design of effective teacher professional development (Gotwals, 2012).

Our learning progressions research uses grounded evidence from students' own performances to characterize students' ways of talking, thinking, and writing as they make sense of the world as they experience it (Gee, 1991). Knowing how students make sense of the world provides a critical lens for designing learning experiences that are responsive to students' ways of reasoning and that can support students in developing more sophisticated knowledge and practice over time.

Because we focus on just a few assessment items in this article, the research and evidence presented here does not represent a complete learning progression on its own. However, this study does build on and fit within the body of our previous learning progressions work that describes less and more formal ways that students make sense of environmental phenomena and systems (Covitt & Anderson, 2018; Gunckel et al., 2012; Mohan et al., 2009). While the results of this study are consistent with the methods and findings of our previous work, they are also unique; we have never published data or results specif ically addressing students' pool-and-flux reasoning before.

The methodological approach of design-based research aims to "blend empirical educational research with theory-driven design of learning environments … [to understand] … how, when and why educational innovations work in practice" (Design-Based Research Collective, 2003, p. 5). In collaboration with schools and teachers that has extended for over a decade, we have used a designbased research approach to develop, test, and refine learning progressions and learning progres sion-informed instructional approaches addressing environmental science literacy (Anderson et al., 2018).

Research context

The carbon TIME project

For over a decade, the Carbon TIME project has enacted a design-based research partnership aimed at studying, testing, and refining a learning progression-based approach to teaching carbon cycling in the United States at the middle and high school levels (Anderson et al., 2018). The Carbon TIMEcurriculum comprises six instructional units: Systems & Scale, Animals, Plants, Decomposers, Ecosystems, and Human Energy Systems (all Carbon TIME materials are freely available at carbontime.bscs.org).

In the sequence of Carbon TIME units, students learn to trace matter and energy through pro cesses such as photosynthesis, biosynthesis, cellular respiration, and combustion at multiple scales—from atomic molecular through global. In the curriculum, carbon cycle pool-and-flux reasoning comes at the end—in the Ecosystems and Human Energy Systems units. Thus, before Carbon TIMEstudents encounter the challenge of global carbon cycle pool-and-flux reasoning, they have had experience with tracing carbon through smaller systems including animals, plants, engines, and ecosystems.

Carbon TIME teachers participated in a professional development (PD) course of study that was embedded in a local professional network (i.e., professional learning community). The course of study, which involved 75hours of participation over two years, included both face-to-face and online PD expe riences with activities including but not limited to experiencing, analyzing, and critiquing units; enacting units and reflecting on instruction; analyzing and responding to student performances; and collaboratively working on problems of environmental science literacy instruction. While tracing matter and energy through systems was emphasized throughout the PD course of study, very little PD time focused specifically on global pool-and-flux reasoning.

Carbon TIME has addressed the NGSS performance expectation for carbon cycle pool-and-flux reasoning (HS-ESS2-6) through conducting research on students' carbon cycle reasoning and through instructional design and implementation based on our own and others' research. In this paper, we present results from two studies. The first was a pilot study that analyzed patterns in students' responses to a pool-and-flux problem. The results of the first study contributed to revisions of the Human Energy Systems unit. The second study examined the impact of that unit on students' carbon cycle pool-and-flux reasoning.

Research questions

Study One (Pilot) Research Question

What are different (and more and less sophisticated) ways students reason about how a 50% reduction in combustion of fossil fuels would affect future atmospheric CO2 concentrations?

Study Two Research Questions

1. How does viewing a diagrammatic carbon cycle model influence students' pool-and-flux explanation and prediction performances?
2. How does engaging in an instructional unit that scaffolds carbon cycle pool-and-flux reasoning affect students' explanation and prediction performances?

Study One: Learning progression research on students' predictions and explanations

Methods

Context and data sources

In Study One we drew on a convenience sample of students of different ages and levels of experience with the purpose of eliciting and describing a spectrum of approaches to carbon cycle pool-and-flux reasoning. Interviews were conducted with 25 undergraduate students (mostly non-science majors) and 5 graduate medical students. Written responses were collected from 93 high school students including 42 ninth grade students and 51 twelfth grade students. Some, but not all of the high school students had previously completed Carbon TIME units. All data were collected in a Midwest state.

In both interviews and written responses, we asked students to evaluate different predictions for how a 50% reduction in combustion of fossil fuels would affect atmospheric CO2 concentrations over time. The question (Figure 4) depicts part of the Keeling curve with dashed lines showing five predictions for atmospheric CO2 concentration from 2016 to 2065. The students were asked to agree with one of five predictions for future CO2 levels and to explain their choices.

We asked students to choose a prediction and explain their choice both before and after they saw Figure 5, which is a quantitative carbon cycling model representation from the Intergovernmental Panel on Climate Change (IPCC) (2001). This model is similar to Figure 3 but uses older data. The carbon cycle pool-and-flux reasoning required in both models is the same. The rationale for asking students to respond both before and after viewing the carbon cycling model representation stems from the use of this type of representation in climate change education and media sources aimed at student audiences, for example, in educational materials presented by The Globe Program (retrieved May 9, 2020) and Project Learning Tree (retrieved May 9, 2020). These programs present the diagrams with minimal consideration of challenges associated with pool-and-flux reasoning, suggesting that the authors expect students to be able to interpret and use the diagrams without much additional support.

If students have difficulty using carbon cycle pool-and-flux diagrams as reasoning tools, as we suspected they likely would, this would suggest that educators who make use of these diagrams in lessons and other materials will need to be aware that in many cases, students may not take away from such lessons the learning outcomes (i.e., understanding how the carbon cycle imbalance affects CO2 concentrations in the atmosphere over time) that educators hope students will achieve. More directed and intensive learning experiences that go beyond just showing and/or explaining the models to students would be needed.

Analysis

We analyzed students' prediction selections and explanations from interview and written responses using established learning progression research methods (Black et al., 2011; National Research Council, 2006). These methods involve iterative cycles of assessment development, implementation, and analysis with combinations of deductive and inductive coding aimed at articulating empirically grounded levels or categories of ways of reasoning about a topic. Consistent with learning progression research approaches, the reasoning categories presented in this study were developed with reference to both emergent themes arising from this study's data and past research including both our own (e.g., Covitt & Anderson, 2018; Mohan et al., 2009; Parker et al., 2015) and others' (e.g., Cronin et al., 2009).

Our analyses were conducted in several cycles beginning with implementation and analysis of inter views in 2015 and 2016 followed by implementation and analysis of written responses in 2017. Across these assessment implementations, we found that students generally responded to pool-and-flux rea soning questions in one of three ways: pool-and-flux model-based reasoning, correlation heuristic reasoning, and good versus bad heuristic reasoning. These categories are described in the Results section.

After categories were developed using first the interview data and then samples from the written response data, two authors separately coded 80 of the remaining written responses (including responses from both before and after viewing the IPCC model) to establish interrater reliability. Weighted Cohen's Kappa for interrater reliability was 0.65, which is considered substantial (Landis & Koch, 1977). The authors compared and discussed codes, came to consensus for disparate codes, refined the coding exemplar, and one author coded the remaining written responses.

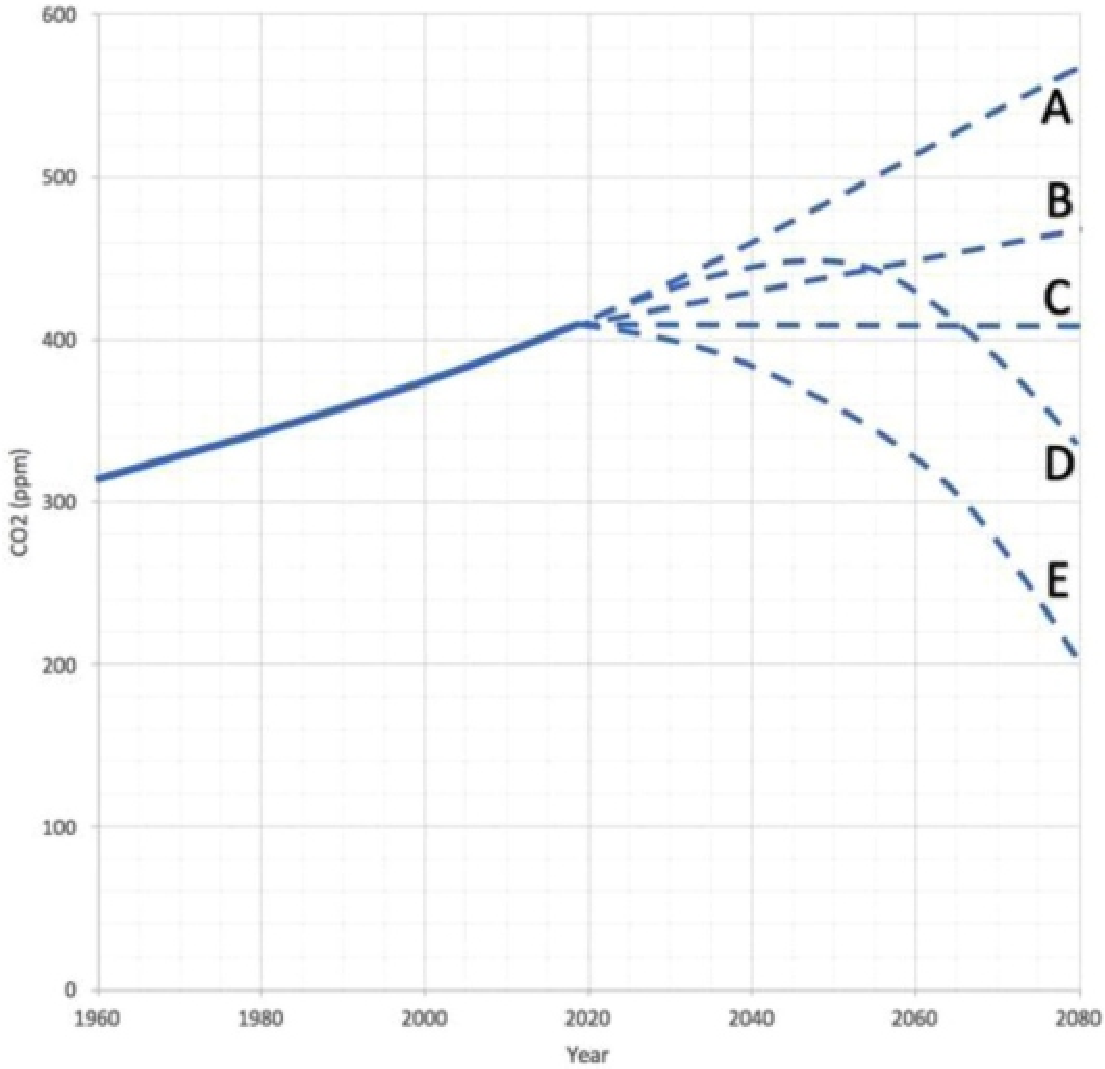

Figure 4. Atmospheric CO_2 prediction question, part 1.
The solid line in the graph shows how carbon dioxide (CO_2) concentrations in the atmosphere changed between 1960 and 2016. If the world were suddenly able to cut its use of fossil fuels in half tomorrow and maintain that low level of use, what would be the effect on the concentration of atmospheric CO_2? Which line best describes what you think would happen to CO_2 levels: A B C D E
Explain your answer.

Results

The students' predictions and explanations fit into three general patterns: pool-and-flux model-based reasoning, correlation heuristics, and good versus bad heuristics. We describe each pattern below, then conclude this section with a discussion of implications for instruction.

Pool-and-flux model-based reasoning

The most sophisticated student responses used the arrows in the IPCC model to calculate a net flux if fossil fuel use were cut in half while the other fluxes were unchanged. These students chose C or D and used the numbers in the model to calculate the net flux of CO2 into the atmosphere given a starting level of emissions of 3.15 GtC per year. Calculating in conjunction with the other fluxes shown in the model, if emissions were to be cut in half, the net flux would be about 0 (or 0.05 GtC per year out of the atmosphere if students included multiple digits in their calculations1). In an example response representing this type of reasoning, the student wrote, "Cutting CO2 from fossil fuels in half would mean 3.15 from processes in the atmosphere. The ocean takes up −2 Gt (88−90), land use takes up −0.2 (0.7−1.9), and −1 Gt from GGP (119-120). This shows that the atmosphere carbon levels SHOULD go down 0.05 Gt a year."

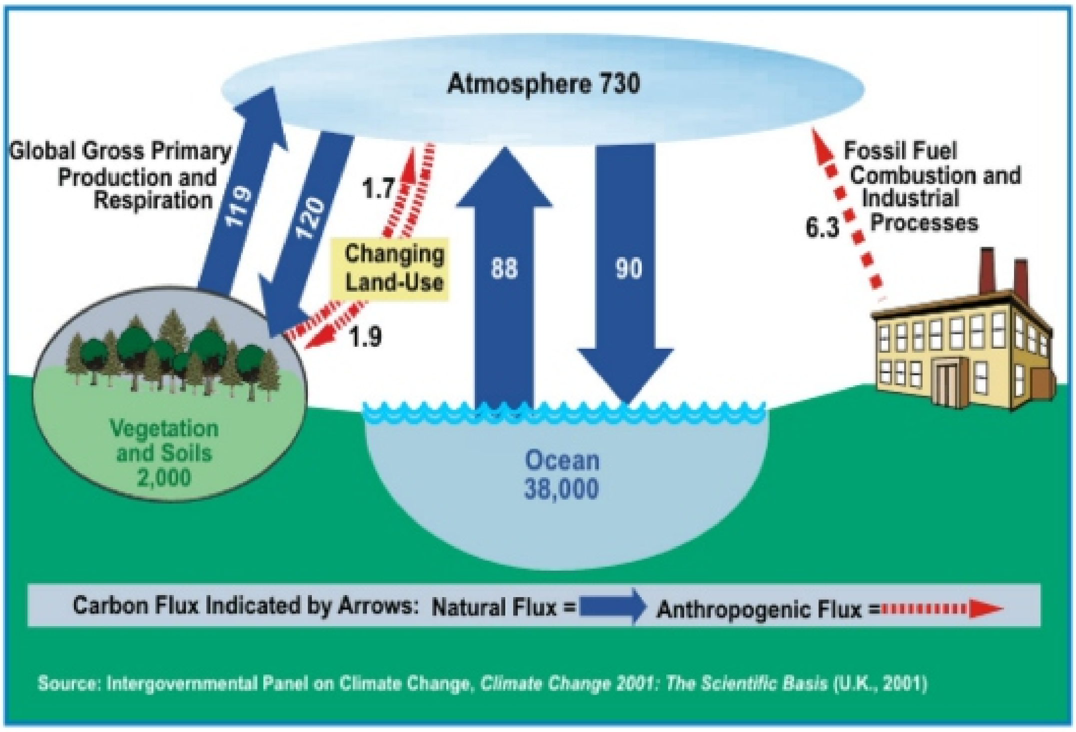

Figure 5. Global carbon cycle model.
The figure to the right shows part of the global carbon cycle. It shows some of the different places or reservoirs where carbon is found on the planet and the amount of carbon in gigatonnes (Gt) in each of those places. The arrows show the number of gigatonnes of carbon that move in and out of the atmosphere every year.

An even more sophisticated level of understanding (which we did not observe in responses from students) would involve choosing response B and explaining that with a reduction in emissions, other fluxes in the model would change as well. For example, the flux arrow from the atmosphere to the ocean would likely decrease due to a negative feedback loop, resulting in the CO2 concentration in the atmo sphere continuing to rise at a less rapid rate over time.

Some students agreed with B and used pool-and-flux reasoning to make a reasonable prediction without doing a calculation. This type of response was evident both before and after the students viewed the IPCC model. These students recognized that changing a flux changes the slope of the line on the graph rather than the value on the Y axis, which represents CO2 concentration. These students explained that if we cut fossil fuel use in half, we would still be using fossil fuels—just not as much. Therefore, atmospheric CO2 concentrations would continue to rise, but at a slower rate. This student's written response is representative of this type of model-based reasoning, "We'd still be producing more CO2 than what gets taken out. So only the rate would slow." While it does not include a calculation, this students' response still represents model-based pool-and-flux reasoning that recognizes the distinction between amount of atmospheric CO2 and rate of CO2 flux into the atmosphere.

Correlation heuristic reasoning

Other students chose D or E and reasoned about pools and fluxes in quantitative but inaccurate or incomplete ways. These students often applied the correlation heuristic, conflating changes in flux (slope of the graphed line) with changes in pool size (value on the Y-axis). The following written response reflects this type of thinking, "D because fossil fuels help to produce CO2 so if we cut it in half it would decrease." Note how this student used "it" twice in the same sentence, perhaps without recognizing that each "it" had a different meaning:

…if we cut it (CO2 emissions—the flux arrow) in half,

…it (CO2 concentration—a measure of the size of the atmospheric CO2 pool) would decrease.

This approach often led to spurious quantitative reasoning, such as when another student conflated a change in flux with a change in pool size, saying, "I guess it would definitely be down here, like 200. … Because we're at 400 right now, so in half."

Good versus bad heuristic reasoning

Other students reasoned in ways that ignored the numbers from the graph and the model. They used an informal frame to explain their ideas about what would happen. These students did not attend to quantitative pools, fluxes, or concentrations at all. Instead, they described things that happen to the environ ment as good (e.g., less pollution) or bad (e.g., using fossil fuels). For instance, some students chose D or E, connecting good actions (e.g., cutting fossil fuel use) with good outcomes without referencing carbon cycle mechanisms: "If it's cuts down and maintain a low level use, the air will clear up and it will be good for animals and humans to breath clean air." Some students chose A based on connecting bad actions to bad outcomes. For example, one student wrote, "[b]ecause I think we've reached a point where we've done too much damage to earth, personally. And I don't think we can come back from that."

Implications for instruction

Over two-thirds of high school students provided responses consistent with the good versus bad heuristic or the correlation heuristic both before and after they saw the IPCC model. Generally speaking, students who provided good versus bad and correlation heuristic type responses before seeing the model did not subsequently use the IPCC model to make pool-and-flux model-based predictions. This suggests, as suspected, that seeing a quantitative pool-and-flux model is not particularly helpful for most students who rely on good versus bad or correlation heuristics.

In general, students who demonstrated capacity to engage in model-based pool-and-flux reasoning were successful with the following three practices:

1. Reasoning using mechanisms (i.e., fluxes between pools) rather than good or bad factors (e.g., pollution) that influence CO2 concentrations.
2. Recognizing and distinguishing between carbon pools and carbon fluxes.
3. Reasoning quantitatively (which does not necessarily require calculations) about multiple fluxes.

With respect to preparation for making informed critiques of solutions as advocated by high school guideline 3.1.C (NAAEE, 2019), we observe a large and meaningful difference in the preparedness of students who engage in "good versus bad" and/or "correlation heuristic" types of reasoning compared with students who engage in "pool-and-flux" reasoning. We concluded that scaffolding pooland-flux reasoning about global carbon cycling should be a high priority for the Human Energy Systems unit.

Study Two: Design-based research on teaching pool-and-flux reasoning

Methods

Context

Study Two examined students' performances before and after they studied the Human Energy Systemsunit (carbontime.bscs.org/human-energy-systems). This unit builds on findings from Study One as well as knowledge and practices that students develop in the previous Carbon TIME units. The first five units support students in developing a repertoire of explanations and evidence-based arguments for tracing matter and energy in combustion and life science contexts at the atomic-molecular, macroscopic, and ecosystem scales. While this repertoire provides a critical precursor, it is not sufficient for employing model-based, global pool-and-flux reasoning. Therefore, the Human Energy Systems unit was designed to scaffold the important practices needed for pool-and-flux reasoning identified in Study One.

The Human Energy Systems unit is divided into two phases. The first phase comprises three lessons in which students look at related time series patterns in data about Earth systems: global temperatures, changes in sea level, Arctic sea ice, and atmospheric CO2 concentrations. Students study the relationships among these patterns, eventually concluding that through the greenhouse effect, CO2 is the driver; changes in CO2 concentrations are driving the changes in the other variables.

This leads to a key question that students subsequently answer in Phase 2 (Lesson 4)—What drives the driver (i.e., what causes CO2 concentrations to go up every year)? Students begin by sharing their own ideas and questions about what is happening. The Human Energy Systems unit is designed to respond to those ideas and questions through engaging students in multiple experiences in which they enact the practices needed for pool-and-flux reasoning while modeling carbon cycling.

Consistent with our iterative, design-based research approach, one significant change made to the unit as a result of Study One was the development of two Global Carbon Cycling models described below. The first model, which students manipulate on their desks, provides a less quantitatively complex intro duction. The second, online model, is designed to support students in modeling and observing the effects of changes in fluxes on the size of global carbon pools over time. These models scaffold students in all three important practices described above: (1) observing and reasoning with mechanisms (i.e., photo synthesis, cellular respiration, and combustion), (2) distinguishing between carbon pools and carbon fluxes, and (3) observing and reasoning about quantitative changes in pools and fluxes over time.

Phase 2 begins with students offering and discussing their own initial explanations and questions concerning the cause of increasing CO2 concentrations. Next, students play a Tiny World Modeling Game (Figure 6), in which they move markers representing carbon atoms among three carbon pools. The carbon fluxes are carbon transforming processes that they have studied in previous units: photosynthesis, cellular respiration, and combustion. In the Tiny World Game, students model (1) a steady state, in which the fluxes are balanced; (2) an annual cycle, in which the photosynthesis flux changes with the seasons; and (3) scenarios that include an unbalanced flux from combustion of fossil fuels.

In a subsequent activity, students use the online Global Carbon Cycling Model (Figure 7) to make global scale, quantitative predictions about effects of changes in fluxes on pool sizes. The computer model has the same pools and fluxes as the Tiny World Model, but pool and flux sizes are based on current global-scale data (Figure 3). Students can control the size and timing of changes in fluxes and see projections of the long-term effects across 50 years. In combination, these activities are designed to scaffold students in developing model-based explanations and predictions for pool-and-flux carbon cycling at the global scale. Students can employ their explanations and predictions to answer the question of what causes atmospheric CO2 concentrations to increase each year

Data sources

Data for the second study come from matched pre and post unit assessments for 415 students who completed the Human Energy Systems unit in 2019. The sample included 77 middle school students and 338 high school students. Students were from schools in three states in the Midwest, Mountain West, and Northwest. Students completed the Human Energy Systems unit in Biology and Environmental Science courses.

In this study, we focus on two items from the Human Energy Systems unit pre- and post-assessments (the full unit assessments include six items). The two items we report on in Study Two are similar to those used in Study One in that they ask students about atmospheric CO2 concentration given a 50% reduction in fossil fuel emissions and in that students respond to the first item before viewing the IPCC model and the second item after viewing the model (Figures 4 and 5). In the first item, students were asked to choose one of five predictions for future atmospheric CO2 concentrations and explain their choice. In the second item, they were again asked to choose a prediction and then they were asked to explain why they did or did not change their previous prediction after seeing the model.

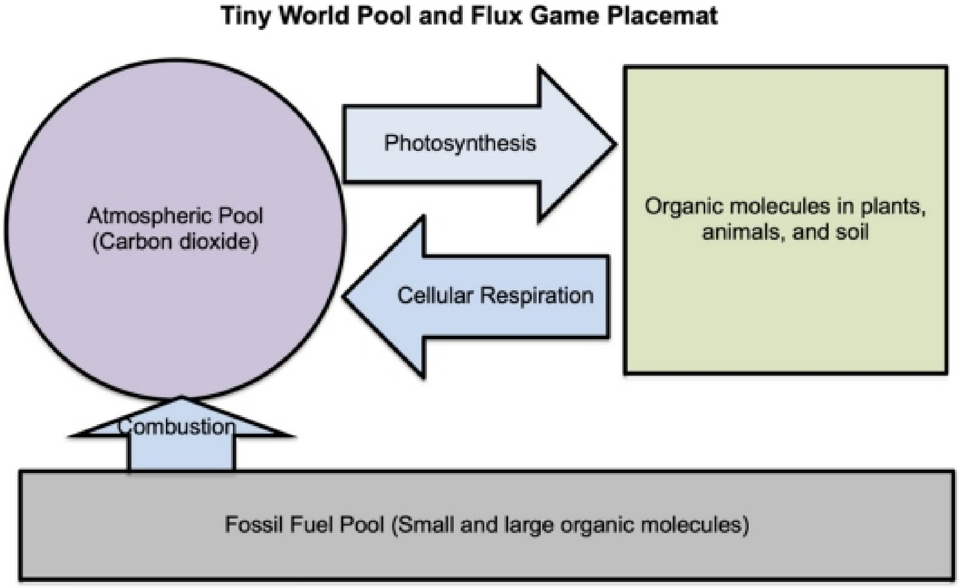

Figure 6. In the Tiny World Modeling Game, students move markers representing carbon atoms through carbon cycle pools and fluxes.

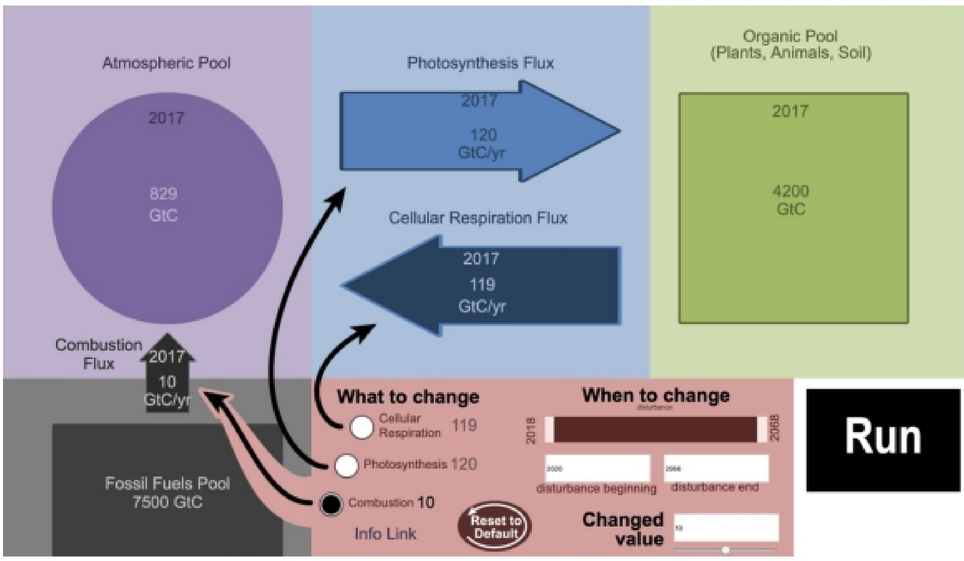

Figure 7. In the Global Carbon Cycling Model, students make predictions for future sizes of carbon pools based on the current size of pools and experimental manipulations of fluxes.

Analysis

Students' item responses were coded into three reasoning levels corresponding to the reasoning levels from Study One. Coding was completed using the *Carbon TIME* machine scoring system developed in collaboration with ACT, an education research and assessment organization. Development, implementation, and validation of the machine scoring system are described in Thomas (2020) and Thomas et al. (2020).

The machine scoring system is based on iterative development and refinement of item rubrics with indicators of each type of reasoning. Rubrics were initially developed and refined with human coders and then machine learning was used to train the Open Source machine-learning engine, Lightside Researcher's Workbench (Mayfield & Rosé, 2013), to code student responses. Machine coding was refined and checked against human coding until a standard of a quadratic weighted kappa (QWK) of at least 0.7 was achieved (Landis & Koch, 1977). Item coding rubrics are available in supplementary materials. Briefly, the descriptors of the coding levels are as follows:

• Level Three (Pool-and-flux model-based prediction and explanation): Responses explain that reduc ing emissions reduces the rate of increase in CO2 concentrations (the slope of the line).
• Level Two (Correlation heuristic): Responses describe incomplete or inaccurate quantitative rela tionships between CO2 emissions and CO2 concentration.
• Level One (Good versus bad heuristic): Responses focus on normative and immaterial ideas about consequences of changing fossil fuel use while disregarding numbers and information about carbon pools and fluxes.

Once data were coded, we applied linear probability models to test several effects described in the Results section below. We examined within-student variation so that students' characteristics are not confounded with the results. A statistical comparison between middle and high school students could not be made because the sample only included middle school students from one teacher. However, it is worth noting that running the probability models with and without the middle school students in the sample did not lead to different results.

Results

Research question 1: Effect of seeing the model

We examined the effect of viewing the diagrammatic model (Figure 5) on students' likelihood of moving to a higher reasoning level by comparing students' performance before and after viewing the model, within the same test. On both the pretest and the posttest, we see only a small change in the percentage of students responding at any given level before viewing the IPCC model (black bars in Figures 8 and 9) compared with after viewing the model (grey bars). The probability of a student responding with good versus bad reasoning decreased by 0.0361 ($p<0.01$) after viewing the model in a test, regardless of whether it was a pretest or posttest—a difference that we judge to be statistically but not educationally significant. The probability of a student responding with pool-and-flux reasoning did not change after viewing the model, again, regardless of whether it was a pretest or posttest.

These findings provide further evidence that offering the diagrammatic carbon cycling model is not very helpful to students who are using the good versus bad heuristic or the correlation heuristic. Instead, it seems that model-based carbon cycle pool-and-flux reasoning is a prerequisite for being able to use the IPCC model in a productive way (i.e., by calculating a net flux and using the net flux to make prediction for future atmospheric CO2 concentration).

Research question 2: Effect of completing the human energy systems unit

The second prominent finding is that completing the Human Energy Systems Unit did have a significant impact. Analysis of the students' performances on the full unit pre and post assessments showed sub stantial learning gains associated with completing the Human Energy Systems unit (average pre to post increase of 0.779 logits representing a paired t value of 16.398, SE = 0.047, $p<0.001$, effect size = 0.799).

With regard to the focal assessment items, while only 27% of students provided responses consistent with model-based pool-and-flux reasoning on the pretest (Figure 8), about 52% of students did so on the posttest (Figure 9). This change reflected an increase in the probability of a student usingpool-and-flux reasoning of 0.252 ($p<0.001$). The probability of a student relying on the good versus bad heuristic showed a decrease of 0.137, $p<0.001$).

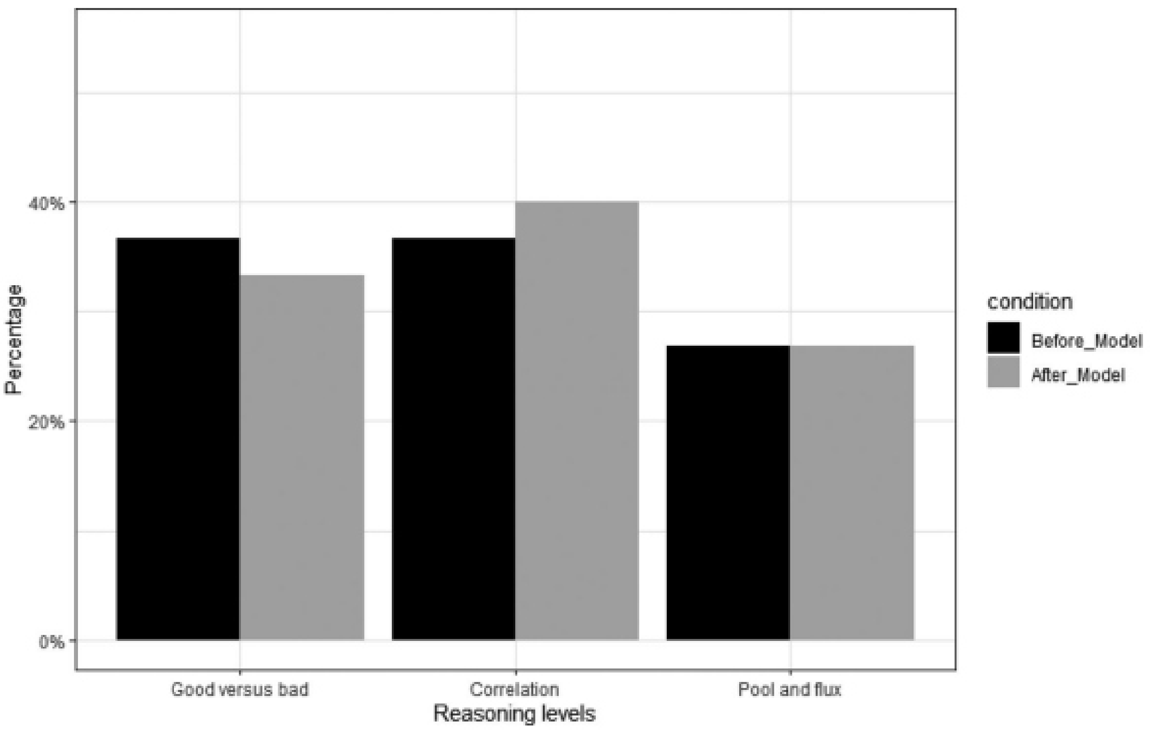

Figure 8. Students responding at each reasoning level on the unit pretest.

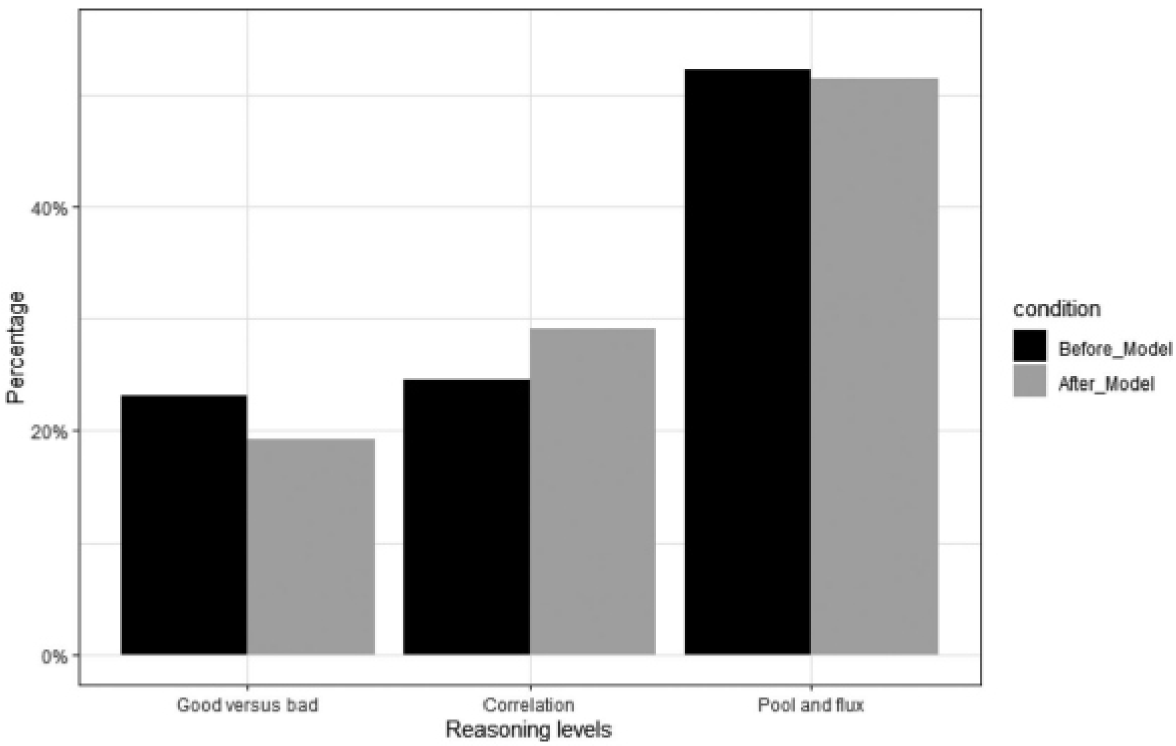

Figure 9. Students responding at each reasoning level on the unit posttest.

While it is encouraging to see an increase from 27% to 52% of students who provided responses consistent with model-based pool-and-flux reasoning, it is important to acknowledge that this result also shows that after completing the unit, about 20% of students still provided responses at the good versus bad heuristic level and about one quarter still provided responses at the correlation heuristic level. These results, while promising, are consistent with previous research studies that have shown the entrenched nature of informal approaches to pool-and-flux reasoning.

Discussion

It is tempting, but problematic, to assume that the meanings of representations like the Keeling Curve (Figure 1) or carbon cycling models (Figures 2 and 5) are transparent to students. The results of our studies are consistent with past research and further elucidate the challenges students face in interpreting and using these representations. The correlation and good versus bad heuristics that we describe above are sometimes useful to all of us; these heuristics help us understand that combustion of fossil fuels is problematic. However, neither of these reasoning approaches helps people understand how multiple fluxes affect CO2 concentration in the atmosphere. In order to evaluate the costs and benefits of different decisions or actions, people need to be able to predict the quantitative impact of changing carbon fluxes on atmospheric CO2 concentration.

We found that without instruction, almost three-fourths of high school students relied on good versus bad or correlation heuristics, even in a situation where the heuristics were inappropriate. This was true even when they were provided with a diagrammatic pool-and-flux model. After completing an instruc tional unit—Human Energy Systems—in which students used both physically manipulated (Tiny World) and computer-based pool-and-flux models, approximately double the percentage (over half) of students could successfully use a pool-and flux model on the posttest. The percentage of students relying on the least sophisticated good versus bad heuristic decreased significantly as well; only about one fifth of students relied on this type of reasoning on the post assessment. Thus, we found that with strategic instructional approaches aimed at scaffolding important practices, most secondary students could apply model-based pool-and-flux reasoning to make sense of and predict changes occurring within Earth's carbon cycle.

Carbon TIME aims to help students recognize problems that require more than heuristic reasoning, and to be able to use model-based pool-and-flux reasoning when they need to. While it is encouraging that Carbon TIME learning experiences helped many students develop capacity for model-based pool and-flux reasoning, we are interested in exploring how educational experiences can be more successful in this respect. To that end, we will continue our efforts to examine how students make sense of carbon cycle pool-and-flux reasoning in the context of interactions with multiple types of models. We hope to find ways to further refine the unit to support greater facility with important pool-and-flux reasoning practices. Ultimately, we would like to see all participating students benefit from these activities by developing model-based pool-and-flux reasoning that they can use in problem solving throughout their lives.

Note

1. While calculating with this precision is problematic because the model is inconsistent with respect to precision of fluxes, we focused our analysis on the conceptual use of the IPCC model as a reasoning tool rather than on the issue of significant figure standards.

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Understanding Austrian middle school students' onnectedness with nature

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ABSTRACT

Fostering pro-environmental behavior to achieve a sustainable society is one goal of Education for Sustainable Development worldwide. Connectedness with nature positively correlates with pro-environmental behavior and therefore needs to be studied in detail. In this mixed-method study, applying the "Inclusion of Nature in Self" (INS)-scale, we investigated 1) how closely preadolescents from urban middle schools (n=651, 6th grade) are connected with nature, 2) whether the type of school (general or academic track) or 3) the time spent outdoors influences students' connectedness with nature. We also explored 4) students' reasons for their specific INS level and 5) how reasons and levels interconnect. Data show that students' reported nature connectedness differs significantly with school type and that the reasons for feeling connected to nature are diverse. Positive attitudes and emotions toward nature plus time spent outdoors seem to predict high connectedness with nature, indicating the importance of direct nature experiences.

KEYWORDS:connectedness with nature; Inclusion of Nature in Self (INS); middle school students; general track; academic track; direct nature experience.

Introduction

Initiated by the United Nations, the present global action plan to achieve a more sustainable future, "Agenda 2030", includes 17 interlinked and integrated Sustainable Development Goals (SDGs) and 169 specific targets (UNESCO., 2015). Researchers identified education as playing a key role in achieving these goals (Otto & Pensini, 2017). Therefore, fostering pro-environmental behavior to achieve a more sustainable society is one of the key objectives of Education for Sustainable Development (ESD). However, in order to create ESD programs or evaluate them, it is important to understand the factors contributing to individuals' tendencies to engage in nature-conserving and environmental behaviors (Richardson et al., 2020). Previous studies indicate that a connection with nature correlates positively with pro-environmental behavior (Dutcher et al., 2007; Kals et al., 1999; Kollmuss & Agyeman, 2002; Otto et al., 2019; Roczen et al., 2014) and might therefore be a crucial determining factor to be fostered in formal or informal ESD contexts. Connectedness with nature is not a new construct: Wilson et al. (1995) assumed that humans have an innate tendency to focus on and connect with other living organisms. This attraction to life and life-like processes, termed the biophilia hypothesis by Kellert and Wilson (1993), can be interpreted from an evolutionary perspective and formed an important interdisciplinary research framework. Humans have spent almost all their evolutionary history in a natural environment, while urban life is a phenomenon of the recent past. This attraction, identification and need to connect with nature is thought to have been preserved in our modern psychology (Kellert & Wilson, 1993).

Nowadays, humanity is losing its connection to nature (Balmford & Cowling, 2006; Kesebir & Kesebir, 2017; Soga & Gaston, 2021), a phenomenon that is defined as "nature deficit disorder" (Louv, 2006). As a reason for that, researchers identified as among some of the key reasons the growing level of digitalization (Kuss & Griffiths, 2017; Michaelson et al., 2020; Pergams & Zaradic, 2007), and a loss of nature experiences (Kareiva, 2008; Pyle, 1993; Soga & Gaston, 2016). Studies show that students recognize more exotic species than local ones (Balmford et al., 2002; Genovart et al., 2013; Lindemann-Matthies & Bose, 2008), indicating that they hardly ever visit nature in their immediate surroundings or have little connection to it. This alienation between humans and nature is one of the potential explanations for the growing environmental problems caused by human activities (Jordan, 2009; Ponting, 2007; Vining et al., 2008).

Nature experiences in childhood and adolescence prove to have significant impact on environmental attitudes, commitments, and actions in adulthood (Cagle, 2018; Chawla, 2020; Chawla & Derr, 2012; Dettmann-Easler & Pease, 1999; Duerden & Witt, 2010; Tanner, 1980; Wells & Lekies, 2006). However, other studies show that it is more difficult to change adolescents' connectedness with nature. (Braun & Dierkes, 2017; Clayton, 2003; Ernst & Theimer, 2011; Gifford & Sussman, 2012). Because of these inter esting findings, we think it is essential to know more about preadolescents' connectedness with nature and at the same time gain further insight into possible reasons for their connectedness with and personal concepts of nature. So far, only few studies focus on preadolescents, and to our knowledge, none include qualitative data such as self-reported information about the reasons for young persons' connectedness with nature (Tseng & Wang, 2020; Zylstra et al., 2014).

Students' connectedness with nature

Connectedness with nature is an important construct in environmental education, conservation education, and environmental psychology. Feeling connected to nature is closely related to personal well-being and mindfulness (Zelenski & Nisbet, 2014). In terms of environmental education, connectedness with nature is associated with pro-environmental behavior and an increase of positive environmental actions (Kaiser et al., 2008). Several studies show that environmental education programs can influence participants' connected ness with nature in a positive way (Braun & Dierkes, 2017; Kossack & Bogner, 2012; Liefländer & Bogner, 2018). In the last 20years, many instruments were developed to measure people's connectedness with nature. The most important instruments in the field of Connectedness with Nature are presented in Table 1.

Table 1. Overview of instruments measuring Connectedness with Nature.

Instrument	Authors (year of publication)	Purpose of Instrument
Emotional Affinity toward Nature Scale	Kals et al. (1999)	Measuring people's emotional motivation for pro-environmental behavior.
Inclusion of Nature in Self	Schultz (2002)	Measuring a person's cognitive dimension of connectedness with nature direct and explicit, based on the self-expansion model of close relationships.
Environmental Identity Scale	Clayton (2003)	Focusing on the role of natural environment in a person's self-definition. Here, environmental identity can be determined by a persons' self-experience, emotional attachment to nature and personal perception of being similar or different from nature.
Connectedness to Nature Scale	Mayer and Frantz (2004)	Measuring connectedness with nature as an "individual's affective, experiential connection with nature"
The Nature Relatedness Scale	Nisbet et al. (2009)	Measuring a person's emotional, cognitive and physical connection to nature. It includes three subscales: self (emotional), perspective (cognitive) and experiences (physical).
Children Environmental Perception Scale	Larson et al. (2011)	Measuring children's perception of nature, children's interest in nature and children's attitudes and concerns regarding nature.
Connection to Nature Index	Cheng and Monroe (2012)	Measuring four constructs of connection with nature: enjoyment of nature, empathy for creatures, sense of oneness and sense of responsibility.

In our study, we refer to the inclusion with nature concept by Schultz (2002) and applied his "Inclusion of Nature in Self" (INS) scale (Schultz, 2002) to assess students' perceived connectedness with nature. The scale reflects the cognitive dimension of connectedness with nature by indicating the amount of overlap of a person's cognitive representation of self with his or her cognitive representation of nature.The more overlap both have, the more a person defines him- or herself as part of nature. The scale is simple to apply, and its test-retest correlations have provided very high reli ability between measurement times (Schultz et al., 2004). Also, compared to other multiple-item scales, the INS scale has been found to be accurate for measuring individual differences in connect edness with nature (Liefländer et al., 2013). The INS scale correlates with other connection with nature instruments (for example the Environmental Identity scale by Clayton (2003) and the Connectedness to Nature scale by Mayer and Frantz (2004); see Table 1). Moreover, the same scale can be used either for children or adults and results from different cultures are comparable (Salazar et al., 2020).

Schultz' concept of Inclusion of Nature (2002) is based on the self-expansion model of close relationships by Aron et al. (1992), which assumes that human relationships are built by integrating others into one's self. It is represented with a Venn-like diagram with seven increasingly overlapping circles. The total area remains always constant. A perception of closeness as an overlapping "self" with another person is consistent with similar approaches in the social psychology literature (Aron et al., 1992). Schultz (2002) extended this model in a way that it enables the integration of characteristics and properties of nature into oneself. He, too, chose circles of equal size for the increasing overlaps. The model is built on the idea that people actively take care of nature if it is perceived as part of themselves.

Research reveals that several factors have an impact on connectedness with nature: gender, age, occupation, ethnicity, and time spent in nature. Regarding time spent in nature, for example, studies show that it is a key factor for a greater connectedness with nature (Braun & Dierkes, 2017; Cheng & Monroe, 2012; Nisbet et al., 2009; Schultz & Tabanico, 2007). However, only a few studies so far investigated the possible influence of students' academic level on their connectedness to nature. Most studies done to date in environmental education research, especially those with questionnaires or tests, focus only on academic track schools (i.e. university-preparatory schools), often due to easier accessibility to the schools and higher reading abilities by the students. In general, knowledge and attitudes of general-education-track students are greatly understudied. This might be a significant mistake, since a study from Liefländer et al. (2013) shows that academic track students are more connected with nature than general track students. In the study reported here we therefore explicitly chose to focus on both groups. To our knowledge, our study is the first in Austria that also includes data of general track students and compares the two cohorts. In Austria, after completing elementary school in 4th grade, students choose between two types of schools: a general track middle school or an academic track middle school. The former usually continue education in vocational schools and the latter mostly continue to college/university (Oberwimmer et al., 2019). In general, students are separated based on their academic achievement in elementary school. Usually, students in general track schools generally stem from lower income households and their parents more often have a nonacademic background (no college or university degree) (Pisa, 2019). The curricula in both types of middle school are equivalent.

The aim of this study is to investigate in depth the connectedness with nature of middle school students in urban areas, looking at both tracks of education, general and academic. Here, we especially focus on their individual understanding, on reasons for and perception of their own connectedness with nature, as connectedness with nature is a key predictor of pro-environmental behavior (Kollmuss & Agyeman, 2002; Otto & Pensini, 2017; Roczen et al., 2014).

Our research questions are 1) How closely are Austrian middle school students (grade 6) connected with nature? 2) Does the type of school (i.e. general or academic track) have an influence on students' connectedness with nature? 3) Does the frequency of time spent in nature have an influence on students' connectedness with nature? 4) Which reasons do they report to explain their level of connectedness with nature? And 5) How do their reasons and their level of connectedness interconnect?

Materials and methods

In this study, we used a mixed-method approach. Next to applying quantifying methods in order to analyze the INS data, qualitative inductive research methods were used, too, in order to gain an in depth insight into students' explanations about their levels of connectedness (Mayring, 2010).

Sample and methods

The sample consists of 651 students from ten schools in Vienna, Austria (grade 6, Mage: 11.63, SD: .85, 45.1% female). 347 students from four general track schools (Mage: 12.04, SD: .81, 45.5% female) and 302 students from six academic track schools (Mage: 11.28, SD: .51, 46.0% female) participated in the study. 70.4% of students from general track schools and 49.3% of students from academic track schools have a migration background. The definition of a migration background is applied to students whose mother and father were both born in a country where students took the questionnaire (Schleicher, 2019). However, the majority of students from both type of schools were born in Austria (85%). 13.3% of general track students' parents and 57.6% of academic track students' parents finished tertiary education. Most parents of students from general track schools work in blue-collar occupations (90.2%), while the majority of parents of students from academic track schools are employed as semi-skilled professionals (32.8%) or as managers and professionals (52.8%). The questions on migration background and socio-economic status were selected and analyzed based on the questions used in PISA (Schleicher, 2019). Data collection was carried out in 2020. The criteria for school selection were their willingness to participate in the research project and had to be either a general track or an academic track school. All schools are public middle schools that are supported financially by the government and provide free education. None of the schools has a focus on specific subjects or offer special education programs. Prior to participation, students were informed about the aims of the research, duration, procedure, and anonymity of the data. Participation was always voluntary, and only students whose parents signed consent forms to participate in the study, were included in the data analysis. Data was collected and analyzed anonymously. Under Austrian law, approval by an ethics committee was not necessary as this study did not involve patients, was noninvasive, and participation was voluntary and anonymous.

Measurements

Students completed an anonymous paper-and-pencil questionnaire. The questionnaire included the environmental attitudes scale "Inclusion of Nature in Self " (INS) (Schultz, 2002), as a direct, explicit measure for assessing cognitive beliefs and detecting perceived connectedness with nature. The INS relies on self-report responses and uses a graphical one-item design, represented by seven circle pairs, labeled "self " and "nature" which differ in the degree of overlap (Figure 1). Students were asked to mark one circle pair in response to: "How interconnected are you with nature? Choose the picture which best describes your relationship to nature." Scores range from 1 to 7, with the least overlapping circle receiving a score of 1 (complete separation from nature) and the most overlapping circle receiving a score of 7 (complete connection to nature) (see Schultz (2002) for details). Four weeks after the INS test, we conducted a retest with 10% of the students. The test-retest reliability for the INS scale provided a Cronbach's α 4-week retest = .90 (N=53) which is in line with test-retest corrections from Schultz et al. (2004) Cronbach's α 1-week retest = .90, Cronbach's α 4 -week retest = .94 and Liefländer et al. (2013) Cronbach's α 4-week retest = .93. Feedback from students in a pilot phase (n=57, Mage: 12.08, SD: .85) did not highlight any problems with understanding the INS scale and the accompanying open question.

To further examine students' individual understanding, perception, and reason for connectedness with nature, the item was accompanied by an open question in which students were asked to explain why they chose their specific INS level. Students were also asked to provide some general sociodemographic information and questions about personal habits concerning nature, such as time spent outdoors.

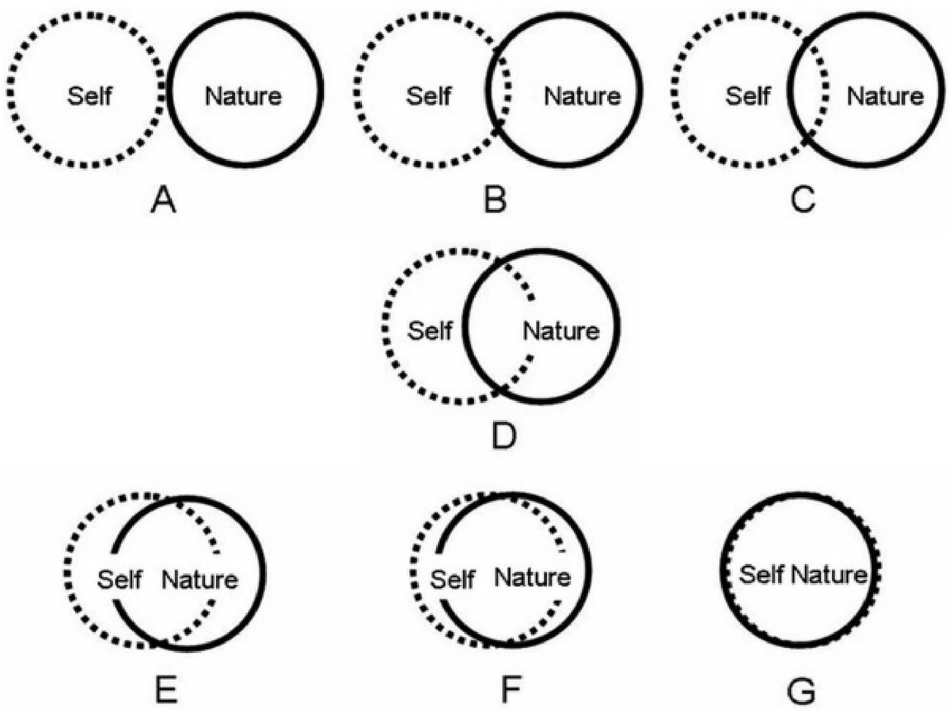

Figure 1. One-item INS scale by Schultz (2002).

Data analysis

The INS scale data from the questionnaire were analyzed using the statistical program IBM SPSS Statistic, version 28. Data obtained were processed at the level of descriptive and inferential statistics. Because INS is measured on an ordinal scale we used the Mann-Whitney U test to analyze the differences between students' connectedness with nature with respect to type of school, frequency of spending time in nature and age of students. The level of significance is .05; the corresponding confidence level is 95%. The effect size r was calculated according to Field (2013) $r = z/\sqrt{N}$, with .10 as a small, .30 as a medium and .50 as a large effect (Cohen, 1960). Spearman rank correlation was calculated for exploring correlations between connectedness with nature level, type of school, time spent in nature and age of students. A total of 658 students' written answers were transcribed, translated from German to English and subsequently analyzed using an inductive-deductive analysis approach performing a Qualitative Content Analysis (Kuckartz & Rädiker, 2019). The analysis was conducted with the Qualitative Data Analysis (QDA) software MAXQDA 2022, which also allowed a semi-quantitative analysis (e.g., occurrence of technical terms). Answer categories are derived from the material itself, performing a qualitative in-depth analysis of the data and inductively established coding categories defined by patterns that emerged in the data. Some categorizations were later redefined and added based on data material and the theoretical frame work. Data that represent less than 2% of answers were not coded. The developed coding guideline includes a clear category definition and an example from the students' answers for each category to verify the transparent categorization. Ten main categories were established, referring to the students' responses. Statements were coded into several categories if they applied to more than one category. Anchor examples are cited from the original questionnaires (see Table 2). The first author and two trained research assistants applied the coding guideline, which was continuously adapted throughout the analyzing process, involving iterative reviews, discussions, categorizing, and coding. We conducted an interrater-reliability test, using Kendall's-W in MAXQDA and a randomly selected sample of 20% of all questionnaires (Kuckartz & Rädiker, 2019; Mayring, 2010). Kendall's W revealed an "almost perfect" (Cohen, 1960) result ($W = .85$).

Finally, the categories were related to the INS statements to investigate possible connections between the students' connectedness to nature and their self-perceived reasons. Based on the model from Kossack and Bogner (2012), three response categories were formed for the purposes of data analysis: low connectedness level (1-3); medium connectedness level (3); and high connectedness level (4-7).

Table 2. Coding guideline ($n = 651$, 658 statements) and examples from the students' answers for each category. Data that represent less than 2% of answers were not coded.

Category		Definition	Example
1.	Positive Attitudes toward Nature	Positive attitudes, feelings	*Because it feels good when one is in nature.* (male, 12 yrs)
2.	Negative Attitudes toward Nature	Negative attitudes, feelings	*I do not like nature so much.* (male, 12 yrs)
3	Low frequency of Contact with Nature	Little time spent outdoors	*I do not have time for nature.* (male, 13 yrs)
4.	High frequency of Contact with Nature	A lot of time spent outdoors	*Because I am often outside in nature, mostly in the forest.* (male, 11 yrs)
5.	Living Close to Nature	Own garden, home close to forest etc.	*I live close to a forest.* (female, 12 yrs)
6.	Activities/Hobbies in Nature	Outdoor activities/hobbies	*I love to walk with my dog in nature and be with my horse out in the fresh air.* (female, 11 yrs)
7.	Importance of Nature	Importance of nature as an ecosystem (ecocentric view)	*Because nature is important for all living organisms.* (female, 11 yrs)
8.	Influence of Family and Friends	Influence of friends and relatives	*Because I often go into nature with my family.* (female, 12 yrs)
9.	Interest in Nature	Curiosity about nature	*Because I think, things in nature are exciting and interesting, for examples animals and plants. (female, 11 years)*
10.	No Interest in Nature	No curiosity about nature	*I am not interested in nature.* (female, 12 yrs)
11.	Environmental Awareness and Protection	Commitment to environmental/ nature/animal protection	*Because I keep nature clean.* (male, 11 yrs)

Results

Results are divided into two main sections: quantitative results of the middle school students' connect edness with nature and qualitative results of students' explanation of their connectedness with nature and qualitative results of students' explanation of their connectedness with nature.

Quantitative results: Middle school students' connectedness with nature

The study shows that Austrian middle school students from an urban area in grade 6 have on average medium to high INS-scores (M=4.30, SD=1.70, n=651).

Our comparison of the INS scores (7-points scale) showed that general track students scored significantly lower on the INS scale (n=354; Mdn = 4.00) compared to academic track students, r=0.14) see Figure 2.

General track students are on average older (n = 354, Mage: 12.04, SD: .81) compared to academic track students (n = 297, Mage: 11.28, SD: .51). To find out whether the age difference introduced bias into the main analysis, we performed an additional analysis, including students in the 11-12 age range only from both cohorts. Results showed that the difference was still statistically significant between groups r = 0.11), therefore we can conclude that age is not a predictor. Regarding their time spent in nature, results show that students spending less time in nature (0 - 3 days) (n = 326; Mdn = 4) have a significantly lower INS score than students who spent more time in nature (4—7 days) (r = 0.23), see Figure

When comparing students' effective time spent in nature (0 - 7days), results show that general track students (n=332; Mdn = 3) spent significantly less time in nature than academic track students (r = .30), see Figure 4.

Next to that, our comparison of frequency of time spent in nature (0-7days) showed that younger students spent significantly more time in nature (n=510, Mdn = 3.00) compared to older students (r=0.17). Additionally, younger students (n=537,Mdn = 4.00) have a statistically significantly higher INS-score compared to older students (r=0.15).

Spearman's rank correlation was computed to assess the relationship between reported INS-scores, time spent in nature, type of school, and age of students. The results are presented in Table 3. The INS is significantly positively correlated with frequency of time spent in nature rs (651) = .378, p < .001, type f school rs (651) = .144, and significantly negatively correlated with students' ages rs (651) = −.165, The frequency of time spent in nature is significantly positively correlated with the type of school rs (651) = .300, and significantly negatively correlated with student age rs (651) = −.250, Type of school is significantly negatively correlated with student age rs (651) = −.503.

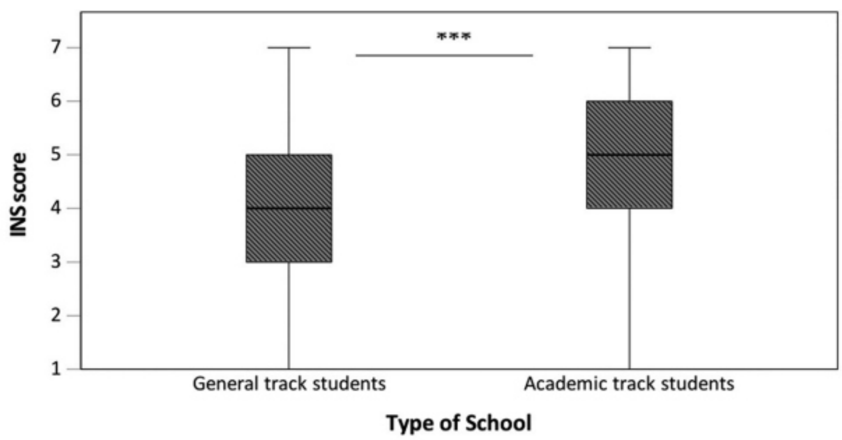

Figure 2. Differences in INS scores according to the type of school (n = 651; general track students (n = 347), academic track students (n = 302), Mann-Whitney *U*, ***significant at p <.001.

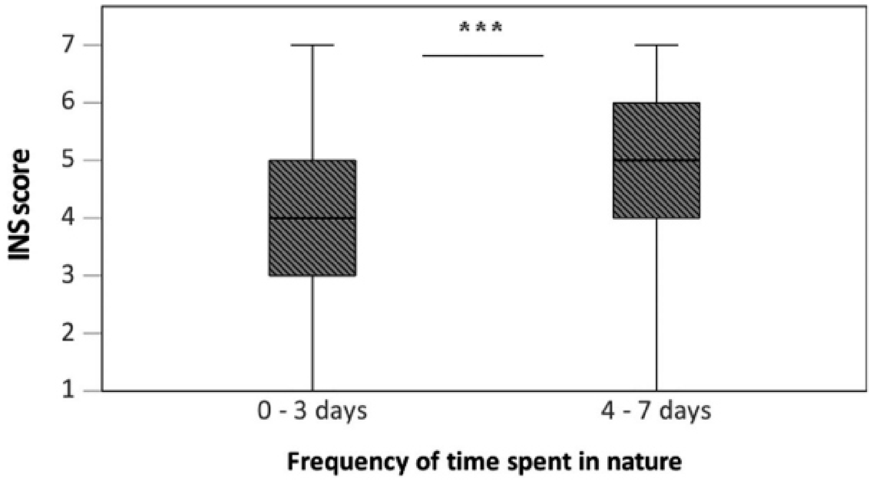

Figure 3. Differences in INS scores according to frequency of time spent in nature (n = 651), Mann-Whitney U, ***significant at p <.001.

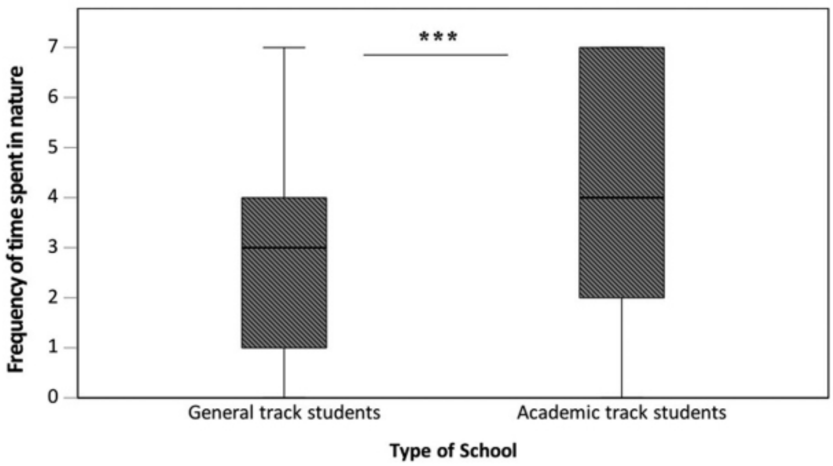

Figure 4. Differences in frequency of time spent in nature according to the type of school (n = 651; general track students (n = 347), academic track students (n = 302), Mann-Whitney U, ***significant at p <.001.

Table 3. Correlation between INS, time spent in nature and school ($n = 651$), Spearman's, ***significant at p <.001.

	1.	2.	3.	4.
1. INS		.378**	.144**	-.165**
2. Time spent in Nature		–	.300**	-.250**
3. Type of School			–	-.503**
4. Age				–

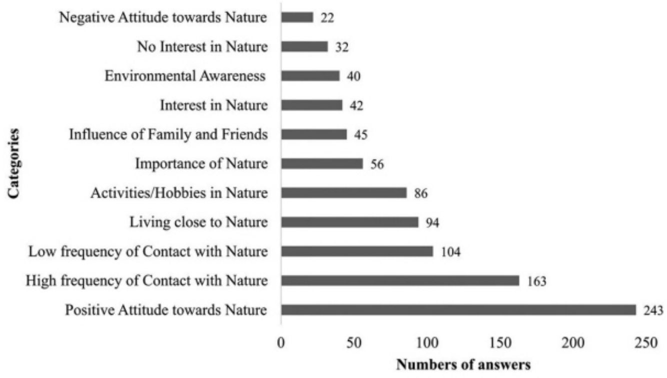

Figure 5. Students' explanation of their connectedness with nature (n=651).

Qualitative results: Students' explanations of their connectedness with nature

When students were asked to explain their connectedness with nature, 658 answers were received in total. The responses were assigned to a total of eleven main categories. Figure 5 illustrates how often each category was found in the students' answers.

Positive attitudes toward nature

Positive attitudes toward nature are the most frequently mentioned explanations for students' connect edness with nature (25.9% of all answers). Students express various positive emotions, such as sympathy, empathy, and respect toward nature. 46.2% of answers in this category stem from general track students and 53.8% from academic track students. Examples included:

• I love animals like deer, eagles and snakes. Nature is always quiet. male, 11 yrs, academic track
• Because I love nature, plants, trees, fresh air. male, 12 yrs, general track

Students also mention esthetic components of nature such as:

• Nature is beautiful. female, 11 yrs, academic track
• I think trees and plants are beautiful! male, 11 yrs, general track

High frequency of contact with nature

High frequency of contact with nature is students' second-highest mentioned category (17.4% of answers) as explanation for their INS score. 24.6% of answers in this category are mentioned by general track students and 75.4% by academic track students. Time spent outdoors is an important value for these students. For example:

• Because I much prefer being outside and enjoying nature than being at home. male, 12 yrs, academic track
• Because I am often in nature (forest, meadow). female, 11 yrs, general track

Low frequency of contact with nature

The third most mention explanation (11.1% of all answers) is a low frequency of contact with nature. 44.2% of answers in this category are from general track students and 55.8% are from academic track students. Students often explain the low frequency of nature contact with a lack of time, as can be seen here:

• I am rarely in nature because I don't have the time. female, 11 yrs, general track
• Because I have to go to school every day and only have time to go outside at the weekend, sometimes not. male, 13 yrs, academic track

On the contrary, some students explain that they spend most of their free time indoors on purpose. Often, they mention screen time as their reason for a low frequency of contact with nature:

• I spend most of my time at the computer or mobile phone and rarely go outside. male, 11 yrs, general track
• I prefer to stay at home and play computer games. male, 14 yrs, general track
• I like to play games on my smartphone, and when I get bored, I go into nature. male, 11 yrs, academic track

Living close to nature

Some students explain their connectedness with nature by referring to living close to nature (10% of all answers). 30.6% of answers in this category are from general track students and 69.4% are from academic track students. They live close to nature, or they have a garden, plants or pets:

• We have many plants on the patio, and I spend a lot of time there. male, 11 yrs, academic track
• Because I love nature and I have pets at home. male, 11 yrs, general track
• Every day after school I go into the forest close to our garden. In the garden, we have raised garden beds and apple trees. male, 11 yrs, academic track.

Some students mention living close to a forest or park:
• I go to the forest three times per week. male, 11 yrs, general track
• Because I often go in the park after school. female, 11 yrs, academic track

Some students mention they had lived close to nature before they moved to the city:
• In Vienna, I do not feel so close to nature, but in Poland, where I lived before, we lived in a village, and I felt more connected with nature. female, 12 yrs, general track
• In the land where my parents come from, we have a house with a garden and trees. I go there twice a year. male, 12 yrs, academic track

Activities/hobbies in nature

Students also describe their connectedness with nature referring to activities and hobbies undertaken in nature (9.2% of answers). 16.1% of answers in this category are from general track students and 83.9% are from academic track students. For example, they mention playing in nature or practicing hobbies in nature:

• I often go outside with my friends, and I often play in the forest. male, 12 yrs, general track
• Doing sports in nature (for example because I love to go mountain biking). male, 12 yrs, academic track
• Because I like to walk in nature and imagine what is there, for example insects, beetles, trees, plants, waters and so on. female, 11 yrs, academic track

Importance of nature

Only a few students (6.1% of answers) describe their connectedness with nature from an ecocentric point of view on nature. 93.2% of answers in this category are from general track students and 6.8% are from academic track students. In their reasoning, nature is not only important for humanity but also for other living organisms:

• Because the environment is important for all of us and I would like to help. male, 13 yrs, general track
• Because nature is important for humanity, and if you throw waste into the sea, 1000 fish (and other animals) can die. female, 12 yrs, academic track

Some students mention air and oxygen:
• Nature is important for us because trees produce oxygen, and we need that. male, 12 yrs, general track
• I want to do something about not cutting down trees because the leaves make oxygen and if we do not have leaves on earth or they cannot grow, we do not have fresh oxygen. female, 11 yrs, general track

Influence of family and friends

Only 4.9% of the answers refer to the influence of their close family, grandparents and friends when describing their connectedness with nature. 37.8% of answers in this category are from general track students and 62.2% are from academic track students.
• Because I always go outside with my family. female, 11 yrs, general track
• I go hiking with my mother every free afternoon. female, 12 yrs, academic track
• It is best to be outside and with friends. female, 11 yrs, academic track

Interest in nature

We sorted 5.5% of answers into the category interest in nature. 79.2% of answers in this category are from general track students and 20.8% are from academic track students. Students describe their connectedness as curiosity about nature; they would like to learn more about nature:
• Because I am interested in nature and can learn new things. female, 11 yrs, general track
• Because I am very often in nature, and I am interested in what happens there. male, 12 yrs, academic track

Environmental awareness and protection
We allocated 3.3% of answers to the category environmental awareness and environmental protection. 75.0% of answers in this category are from general track students and 25% are from academic track students. Some students mention a loss of biodiversity:

• I do not want to pollute our world so that animals will not die, for example polar bears, penguins. female, 11 yrs, academic track
• Because the environment is very important, and many animals are becoming extinct, I love animals so I will do everything in my power to save them. male, 12 yrs, general track

Some students mention pro-environmental behavior:
• Because I am careful with nature, so I take care of nature. female, 12 yrs, general track
• Because the environment is important for all of us, and I would like to help. male, 11 yrs, academic track

No interest in nature

Only a few answers (4.3%) were categorized into the category "No Interest in Nature". 90.6% of answers in this category are from general track students and 9.4% are from academic track students. Some examples are:
• Because unfortunately, I do not care! male, 11 yrs, general track
• Because I am more interested in other things than nature. female, 13 yrs, academic track

Negative attitudes toward nature

Only a very few students (2.3% of answers) express negative emotions toward nature, such as fear or boredom. 56.6% of answers in this category are from general track students and 44.4% are from academic track students.
• Because it is boring. male, 11 yrs, general track
• I am afraid of nature. male, 12 yrs, academic track

Some students mentioned a dislike of insects:
• I hate insects and I don't care about nature. male, 13 yrs, general track
• I do not like nature because you can find many insects there. female, 11 yrs, academic track

Linking students' explanation of their connectedness with nature with their INS level

In a more in-depth analysis, we compared students' explanation of their connectedness to nature with their INS level (Table 4).

Clearly, students with a high INS score (5-7) and a middle INS score (4) particularly often stated positive attitudes toward nature and reported higher frequencies of contact with nature as the reason for their level of connectedness with nature. Students with lower INS scores (1-3) most often mentioned low frequencies of contact with nature, and consequently, only a few students with lower INS scores mentioned activities in nature to explain their connectedness with nature. Students with lower INS scores often reported no interest in nature as an explanation for their low connectedness with nature (Table 4). Students with a high INS score (5-7) and middle INS score (4) mostly explained their connectedness with living close to nature, activities, and hobbies in nature (anthropocentrism). In thecase of ecocentrism, we found the importance of nature mostly mentioned by students with high INS scores. Moreover, the category "importance of nature" shows the biggest gap between students with high, middle, and low INS scores. Difference between students with different INS levels (high, middle, and low) and categories based on their explanation for nature connectedness proved to be statistically significant, for all categories except for the categories "Influence of Family and Friends" as well as "Interest in Nature". (Table 4).

Table 4. Students' Explanations of their Connectedness with Nature in comparison to their INS level, Pearson's Chi-square test p. significant p-values are shown in bold, difference is significant at level p <.001**.

Category	Total N	Low INS score (1-3) *f (f%)*	Middle INS score (4) *f (f%)*	High INS score (5-7) *f (f%)*	P
Positive Attitude toward Nature	243	34 (14)	63 (25.9)	146 (60.1)	**< .001**
High frequency of Contact with Nature	163	17 (11.5)	48 (27.9)	98 (60.2)	**< .001**
Low frequency of Contact with Nature	104	63 (60.6)	29 (27.9)	12 (11.5)	**< .001**
Living close to Nature	94	13 (12.7)	28 (29.1)	53 (58.2)	**<.001**
Activities/Hobbies in Nature	86	8 (9.3)	30 (34.9)	48 (55.8)	**< .001**
Importance of Nature	56	6 (10.5)	7 (12.3)	44 (77.2)	**< .001**
Influence of Family and Friends	45	10 (22.2)	17 (37.8)	18 (40.0)	.230
Interest in Nature	42	10 (19.2)	12 (23.1)	30 (57.7)	.104
Environmental Awareness	40	7 (17.5)	10 (25)	23 (57.5)	**< .001**
No Interest in Nature	32	31 (96.9)	1 (3.1)	0	**< .001**
Negative Attitude toward Nature	22	15 (68.2)	7 (31.8)	0	**< .001**

Discussion

Young people are vital stakeholders in behavioral change toward a more sustainable future. Connection with nature is considered an important factor in behavioral change toward a more sustainable lifestyle. Studies indicate that it correlates positively with self-reported pro-environmental behavior (Dutcher et al., 2007; Kals et al., 1999; Kollmuss & Agyeman, 2002; Otto et al., 2019; Roczen et al., 2014) and might therefore be a determining factor that should be fostered in formal or informal ESD contexts. Because of this, the aim of this study was to investigate in depth the connectedness with nature of middle school students in grade 6 in urban areas in Austria. We chose grade 6 because so far, only few studies focus on preadolescents, and to our knowledge, none include qualitative data (Tseng & Wang, 2020; Zylstra et al., 2014). We were particularly interested in general track students who are still greatly understudied. We were also interested in comparing the two school tracks, general and academic. Our second focus was an in-depth analysis of students' individual reasoning and personal perceptions of their own connectedness with nature.

Middle school students' connectedness with nature

In answer to our first question about how Austrian middle school students are connected with nature, the results show that participating middle school students in Austria show middle to high INS scores (M=4.45), which is in line with previous studies (Braun & Dierkes, 2017; Bruni et al., 2017; Fränkel et al., 2019; Liefländer & Bogner, 2014). Bruni and Schultz (2010) reported that 10- to 11-year-old students from California (U.S.) had INS scores of 4.45 on average, which is almost the same average level ofconnectedness as our Austrian students. It indicates that preadolescent students are still more connected with nature than adults or teenage students over 12 years.

Middle school students' connectedness with nature related to the type of school

However, in our present research, although all students were in grade 6, their age ranged from 10 to 14 years. This was mostly due to older students in the general track school. In Austria's school system, students must repeat the whole grade if they fail several classes. Students who attend grade 6 at 13years or older repeated at least one grade.This may have many reasons, above all presumably language barriers: students with immigrant roots on average have a poorer knowledge of the German language and thus have more difficulties following the lesson. Thus, sixth-grade students in our sample that stem from academic track schools were on average younger than in the general track schools. Related to age, we found that younger students (11-12 years) had significantly higher

INS scores than older students (13-14 years). Similar results were reported by previous studies (Braun & Dierkes, 2017; Liefländer & Bogner, 2014), suggesting that environmental programs are more effective with students under 12. We found a statistically significant difference concerning the INS level between students in general and academic track schools. To find out whether the above reported age difference introduced bias to our results, we performed an additional analysis, only including 11-12-year-old students from both cohorts. Results showed that the difference was still statistically significant between groups, therefore we can conclude that age is not a predictor in our study groups. The differences in connection with nature among general and academic middle school students was also found in a German study conducted by Liefländer et al. (2013), that found statistically significant differences in connection with nature in favor of academic track middle school group of students.

Middle school students' connectedness with nature related to time outdoors

In addition, our results also show that students from academic track schools spent more time in nature than general track students. Time spent outdoors is a strong predictor for connectedness with nature (Fränkel et al., 2019; Schultz, 2002). Hence, the differences in INS outcomes between students of these two types of schools require a more complex explanation. Austria is one of eight countries in the Organization for Economic Cooperation and Development (OECD), where students are differentiated at age 10 based on their achievements in a primary school (Pisa, 2019). However, formal entrance exams are not obligatory, and parents can influence the school choice. Often parents with a higher socioeco nomic status prefer that their children attend higher-achieving schools (academic track schools) that cater to students who are on track to attend university (Oberwimmer et al., 2019). Parents with lower income and lower levels of formal education often have fewer opportunities to attend recreational outdoor activities in nature outside of urban areas, which could partially explain our findings. In our study, students from general track schools reported spending more time indoors and rather attend activities in local city parks. Studies from Seattle and San Diego (U.S.) (Tandon et al., 2012) and Finland (Kantomaa et al., 2007) also show, that students with a lower socio-economic status spend more time indoors. General-track students also show lower INS score in studies from Liefländer et al. (2013), and Bruni and Schultz (2010); their results indicate that higher INS scores of students are positively related to a higher level of education of their parents. One solution might be that these deficits could be partially offset by education. Formal or non-formal education programs alike should offer more opportunities to increase direct nature experiences (for example field trips or camps) for this group of students. This could include forests and meadows, but also nature environments in urban areas, like parks and gardens. ESD with direct nature experiences should be an explicit part of the curriculum for general track middle school students and should not merely be considered an extra-curricular activity. Here we propose place-based education, an educational approach based on the idea of actively linking schools with their local com munities (Cincera et al., 2019; Smith, 2002; Sobel, 2004). Additionally, it is essential that students can also experience nature in their free time and not only in an education context. Here, federal states, cities, and municipalities could provide free offers for nature experiences such as free transport and entrance to national parks, nearby forests, or lakes. These offers should not only be granted for students alone but for whole families and communities.

One of the reasons for differences in INS scores between students could also be due to diverse cultural backgrounds. Most of the participating students (83%) were born in Austria but 70.4% of student from general track schools and 49,3% of students from academic track schools have migration backgrounds. Some students who were not born in Austria mention they had lived close to nature before they moved to Vienna (see student's answers in chapter "Lining close to nature").

Middle school students' explanation of their connectedness with nature

An in-depth qualitative analysis of the students' individual reasoning and personal perceptions of their connection with nature reveals different understandings of the concept of connection to nature. Our findings show that a higher frequency of contact with nature and a positive attitude toward nature are the most common explanations of students' connectedness to nature. The higher the frequency of contact with nature is also consistent with the quantitative part of our results. Students' reasons for connectedness with nature are very diverse and interconnected with their level of connectedness with nature.

Students that are more connected with nature mention frequent activities in nature and often explain that they live close to it. Students less connected to nature rarely mentioned activities in nature, which could be explained by the so-called "extinction of experiences" (Pyle, 1993). Studies show that people who live far from nature or close to degraded areas spend less time outside (Neumayer, 2003; Soga & Gaston, 2016). However, that should not be the case in our study, since the study was conducted in Vienna, where 53% of the area is covered with green areas and water bodies (Vienna City Statistical Yearbook, 2020). Students who explained their low INS score with a low frequency of contact with nature often mentioned that they preferred to spend their time online or at the computer and smartphone and that they do not have any time for nature, here we found no difference between general and academic track schools. Bruni and Schultz (2010) and Larson et al. (2019) also found that students who reported spending more time outdoors have a higher connectedness with nature. Time spent in nature is proven to be one of the most important factors affecting students' connectedness with nature (Fränkel et al., 2019; Kals et al., 1999; Mayer et al., 2009; Schultz & Tabanico, 2007). The issue here is how students spend their time in nature and what they understand by the term nature. Understanding the concept of nature is essential for understanding the concept of connectedness to nature. The links in the perception of the concept of nature and connectedness to the perception of connectedness to nature need to be further explored. In conclusion, we would like to add that the results of our study have clearly shown the importance of complementing quantitative scales with open-ended questions to clarify students' understanding and perception of constructs, in our case, connectedness to nature. Additionally, different reasons lead students to the same result on the INS scale; in order to find out how formal or informal teaching interventions can possibly increase connectedness with nature or pro-environmental behavior we need to know their motivations, reasons, and perceptions of connectedness with nature in greater detail.

Limitations

The study was conducted with students living in an urban area, but it would be interesting to compare the results with preadolescents from rural areas, too. To get a better insight into students' connectedness with nature, various scales about connectedness with nature could be implemented in future research. One of the limitations of the study is that we did not conduct additional interviews with the students in order to get more in-depth information about their personal conceptualization of the concept connectedness to nature. For example, it would have been interesting to find out more about the concept of the term nature of those students that indicated a low INS score and reported that they do not care about nature. In general, more qualitative data about students' understanding of the concept of nature and about their activities in nature would additionally help in understanding preadolescents' connectedness with nature, especially to better understand the difference between the two types of schools. A limitation of the study is also that we were not able to further investigate the cultural background of students that were not born in Austria. Students' roots in other countries might also be a reason for the differences in their level of connectedness with nature and understanding of connectedness with nature (Fränkel et al., 2019). Another limitation might be the fact that when students were asked about their time spent outdoors, they were to report how many days per week on average they spent outside in nature. Larson et al. (2019) suggests that it is better to ask about hours per day; this way students can more easily calculate their time outdoors. Also, instead of questionnaires using an open-ended question, it would be interesting to use nature diaries, in which students can describe their time outdoors, their activities and their connectedness with nature in detail (Ardoin et al., 2020; Michaels et al., 2007).

Conclusion

Our study shows that students from urban middle schools in grade 6 on average have medium to high INS scores. Academic track students' connectedness with nature was significantly higher than general track students. Also, the more time students spent outdoors the higher they report their connection to nature. Therefore, especially general track students at preadolescent age might benefit from more time in nature, preferably through an environmental program with direct nature experiences. This is also indicated in students' explanations for their self-reported connectedness with nature.Therefore, we suggest that direct nature experiences should be part of the curriculum for middle school students, not only in biology lessons but possibly interdisciplinary based on the place-based education approach, where students can learn and be in touch with their local environment. Our research also indicates that the reasons for feeling connected to nature are diverse and seem to highly depend on positive attitudes toward nature and time spent in nature. Here, we suggest that additional open questions should accompany quantitative research scales more frequently to get a broader and more detailed view of the topic. Our research is based on the INS Model, in which the main idea is that people actively protect nature only if they perceive themselves as part of it (Schultz, 2002). Our results indeed show that students who perceive themselves as part of nature often describe their high connectedness with activities and hobbies in nature. Students who live close to nature detect the importance of nature for humans and other living organisms. Therefore, loving and feeling connected to one's (local) environment might apparently help to protect nature more effectively. However, at the same time our data suggest that it probably needs a whole-of society approach with policy decisions that enable people to spend (more) time in nature, for example through free education programs based on the place based education. This will become increasingly important in the near future as it is estimated that by 2050 two out of three people are likely to live in cities or other urban centers (United Nations Population Division, 2019), where access to nature will be even more difficult.

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The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250-Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the Text

Citation in the text must be uniform. When citing references in the text, use the reference number set in square brackets from the Reference list at the end of the article.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.

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