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EcoHealth as a Curriculum Aim in Science Education

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Abstract
School science education needs to change its aims, content and pedagogies if it is to prepare students for the challenges of the Anthropocene. Climate change is the single biggest health threat facing people and other organisms. We argue for embedding EcoHealth as a curriculum aim within school science, as well as other subjects. Findings from a study undertaken in Egypt are presented, where a critical realist approach was employed, in part because of critical realism's distinction between reality and our knowledge of reality, and in part because of its treatment of absence. A documentary analysis of the Egyptian school curriculum was conducted to examine how climate change and its health impacts are dealt with and 34 secondary students and seven teachers were interviewed across seven schools to explore their understandings of climate change and its health effects. The analysis shows stark absences in teaching and learning about climate change in Egyptian schools and little understanding or recognition of its health impacts. The findings are used to argue for a Vision III science education for climate change education in the face of environmental decline and future uncertainties. Limitations of the study include a relatively small sample size for the number of interviews undertaken, limited time to collect data due to bureaucratic delays in issuing official permissions to access schools and a paucity of existing research on this topic in Egypt. Future research could determine how the Egyptian curriculum and classroom practices are addressing the worsening climate emergency.

Keywords Climate change · EcoHealth · Critical realism · Egypt · Curriculum aims · Science education

Introduction

Contemporary science education exists in a landscape characterised by rapid technological advances within a highly connected and globalised world that is, nevertheless, in certain ways deeply fragmented (McCrory& Reiss, 2023). More and more people in an increasing

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number of countries are able to communicate in real time across the globe and an increasing proportion of the world's population has virtually instantaneous access, given the necessary financial resources, to information, goods, services and each other via the internet. But it often feels that our collective ability to make wise decisions is unable to keep pace with this rapid technological change that is happening at a time when there are, or seem to be, increasing international and intranational inequalities and escalating existential threats to humanity from climate change, other ecosystem damage, zoonoses and so on (Reiss, 2023). This manifests in greater uncertainty about what the future might look like and increased concern at these changes (Beck, 1986/1992). Such concern is indicated by a rash of dystopian novels, such as Margaret Atwood's The MaddAddam Trilogy (published in 2003, 2009 and 2013) and Kazuo Ishiguro's *Klara and the Sun* (in 2021), and such films as *The Hunger Games* series (in 2012, 2013, 2014, 2015 and 2023), *Under the Skin* (in 2013), *Snowpiercer* (in 2014), *Ex Machina* (in 2015) and *Blade Runner 2049* (in 2017).

In recent years, science curricula and writings on the aims of science education have begun to respond to this background in ways that go beyond the well-known Visions I and II of science education:

> Vision I looks inward at science, to build curriculum from its rich and well-established array of techniques and methods, habits of mind, and well-tested explanations for the events and objects of the natural world … Vision II, developed later in the history of school science, begins by looking outside science to build curriculum that illuminates how science permeates and interacts with many areas of human endeavor and life situations. These societal issues and individual life situations usually include political, economic, and ethical considerations. This view is sometimes called science for citizenship, concentrating on matters of more obvious personal and social relevance to students than preparing to grasp more demanding science they might or might not study.
> (Roberts & Bybee, 2014, p. 546)

More recently, Sjöström and Eilks (2018) have proposed what they term 'Vision III', a humanised science education that includes 'critical scientific literacy' and 'socio-political action'. Vision III therefore builds on earlier ideas of such authors as Hodson (1994), Roth and Barton (2004) and Aikenhead (2007). This vision aligns with the increasing perception that it is now critical to educate school science students, our future leaders, decision makers and other citizens about socio-ecological challenges (IPCC, 2023). To do so requires science curricula and pedagogies that take account of societal and ethical entanglements (Ferguson & White, 2023; Funtowicz & Ravetz, 2018) and student identities and aspirations (Tytler & Ferguson, 2023). This opens up the possibility of a more post-humanist approach to science education, one that avoids the separation of humans and nature, giving more weight to an interconnected view of the natural world.

Of the various health threats to both humanity and the rest of the global biome, climate change is widely perceived as the biggest (WHO, 2021). However, tackling climate change could also be the greatest health opportunity of the twenty-first century (Watts et al., 2015). Not only should climate change be given more space and time within curricula, including, but not only, school science curricula (Dillon, 2012), but its threats to all dimensions of human health need to be more widely recognised within schools, especially given that eco anxiety and eco grief are becoming more prevalent amongst young people (Ojala et al., 2021). Furthermore, the impact of climate change on biodiversity is also greatly affecting the health of other organisms, with adverse effects including changes in species habitats and compositions, with consequent changes in ecosystem functioning (Nunez et al., 2019).

At the same time, the academic literature in science education on how schools are responding and should respond to the climate emergency is, unsurprisingly (given the global distribution of academics in science education), dominated by examples from the Global North. In this article, we therefore draw on data from a study undertaken in Egyptian secondary schools. Our aim is to examine understandings of the health consequences of anthropogenic climate change in this setting, employing the concept of EcoHealth and considering arguments drawn from the literature on human rights, to argue for a richer conceptualisation of science education than is usual in classrooms.

Background Literature

EcoHealth

The interdisciplinary and cross-disciplinary investigation of socially relevant issues at the juncture of human, animal and ecological health has gained increasing recognition in research since the onset of the COVID-19 pandemic, and has become significant for education, especially within science education (Heuckmann & Zeyer, 2022). The term EcoHealth has been used to spell out the interface between education, health and the environment (Harrison et al., 2019) and this article adopts the concept of EcoHealth, argues for its applicability within school (science) education and develops a critical realist framework to embed the health impacts of climate change in the curriculum. Figure 1 suggests how

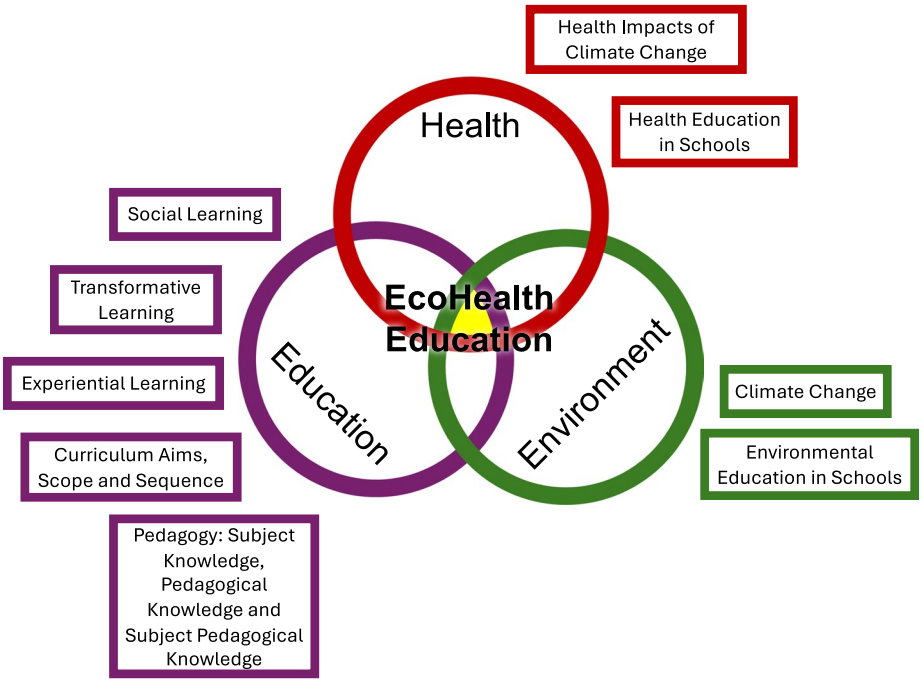

Fig. 1 EcoHealth education can be understood as the intersection between the environment, health and education

EcoHealth education can be conceptualised as the intersection between the environment, health and education.

Little research has been conducted about climate change and its health impacts in schools and most such studies have focused on a narrow approach. Ramadani et al. (2023) conducted a search which covered five electronic databases focusing on English peer-reviewed publications from 2000 to May 2022 but found only nine studies from various countries. These studies had varying foci, including heatwaves, disaster preparation, flood education, vector-borne diseases, and general climate change and health adaptation; some utilised climate change and health topics to develop students' skills, employ ICT within curricula, and emphasise the interconnectedness between the environment and health. Ramadani et al. (2023) found that in five out of the nine studies in which evaluation was conducted, interventions impacted knowledge, awareness or perception. Two studies also highlighted the intergenerational learning potential of the interventions.

No school-based studies have been found to use the term EcoHealth or suggest it as a curriculum aim. In this article, we justify the choice of EcoHealth as a term, employ a critical realist approach to education for sustainability (Khazem, 2018) and provide a framework for integrating EcoHealth as a curriculum aim within education. We argue that education, within and outside schools, is an important sectoral and systemic approach that can help sustain the health of our planet and its people. Introducing EcoHealth as a curriculum aim would help ensure that young people are not only informed about the impact of the environment on their health, but also learn how living healthily and sustainably, and acting both individually and collaboratively, can have a positive impact on themselves and the environment. This interconnected, interdisciplinary focus can go beyond raising awareness, aiming at promoting action and engendering creative and novel approaches and socially robust ideas and solutions to the wicked problem of climate change. The synergy and co-benefits involved, especially in relation to the health impacts of climate change, may help students overcome unhelpful separations between people and place, equity and ecosystems, society and nature – especially in relation to their health and well-being and that of the planet (Parkes, 2015).

Health as a Right

The late 1970 s witnessed an international reaffirmation of health as a human right. In 1978, the WHO-UNICEF Alma Ata Declaration stated in its first paragraph that: "health, which is a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity, is a fundamental human right" (WHO, 1978, paragraph 1). Children have a fundamental right to have protection of their health in order to secure their survival and development. This right has been secured under Article 6 of the UN Convention on the Rights of the Child (CRC) that entered into force on 2 September 1990 (General Assembly of the United Nations, 1989). Article 24 of the CRC also states that children have the right to enjoy "the highest attainable standard of health" (General Assembly of the United Nations, 1989).

In 2002, The United Nations General Assembly adopted Resolution S-27/2, "A World Fit for Children" which calls for the participation of young people as citizens (United Nations General Assembly, 2002, point 9). Point 36f and Point 37.3 of the resolution also called for national programmes and policies for adolescents and the need to address effectively the promotion of their health.

UN international standards have also linked the right to health to a healthy environment. The environment is mentioned in the International Convention on Economic, Social, and Cultural Rights (ICESCR) in Article 12(2) on the right to health (United Nations General Assembly, 1976). The Bangkok Statement, released after The International Conference on the Environmental Threats to the Health of Children: Hazards and Vulnerability, held in Bangkok, Thailand, in 2002, also links the right to health to supportive environments:

> That all children should have the right to safe, clean and supportive environments that ensure their survival, growth, development, healthy life and well-being. The recognition of this right is especially important as the world moves towards the adoption of sustainable development practices. (https://www.who.int)

Furthermore, the UN Conference on Environment and Development, held in Rio De Janeiro, Brazil, in 1992, adopted three non-binding instruments, one of which was the Rio Declaration. Principle 1 of the Rio Declaration states that human beings are "at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature" (UNCED, 1992). Principle 10 of the Rio Declaration also recognised the importance of access to information for citizens to lead a healthy life in a healthy environment. It called on states to "facilitate and encourage public awareness and participation by making information widely available" (UNCED, 1992). Finally, Principle 21 stresses the importance of involving young people in ensuring a better future for all.

International standards have thus made it clear that children have a right to health, including the right to live in healthy environments in harmony with nature, as well as information about health. However, international human rights discourse has been a source of contention, especially amongst post-colonial scholars, who criticise UN universal human rights as Western constructs linked to the projects of Colonialism and Imperialism and accuse human rights discourse of having a normalising power that diminishes but does not overcome injustice and oppression (Bell et al., 2001; Douzinas, 2007). Mutua (2002) contends that human rights discourse, though well-meaning, is mostly Eurocentric and aims at reconstituting the cultures of non-Western societies and changing their practices and norms. Others go further to say that human rights narratives act as a mythology of justice and an ideology and political agenda which justifies loss and normalisation and provides states with arguments for war and military intervention (Frankenberg, 2014; Orford, 2003). Further criticisms maintain that human rights are based on individualistic and secular values which disregard other values and bonds such as religious beliefs and community-based ties. Kennedy (2004), for example, criticises how framing environmental demands as a human rights violation may exclude people from considering the possibility of more collective responses. As such, the focus on the individual within the human rights discourse may be alienating and can restrict both the language and the imaginative space of emancipation through collective and communitarian action (Frankenberg, 2014). Furthermore, poverty and the dearth of economic resources, linked to foreign debt and the associated high interest paid to rich countries in the Global North, mean that countries in the Global South are restricted from securing many human rights for their citizens or combatting climate change. For example, according to Egypt's Second Updated Nationally Determined Contribution 2023, real growth in the country has declined, some key Egyptian economic sectors continue to suffer and foreign debt is soaring. This prompted the Central Bank of Egypt in March 2022 to depreciate the exchange rate of the local currency by around 16% to stem the widening net exports deficit. These inflationary pressures meant that the Government had to intensify its poverty reduction efforts. All these factors limit Egypt's ability

to allocate future climate investments, including within education (UNFCC, Egypt's Second Updated Nationally Determined Contribution, 26/6/2023).

Although the notion of human rights is not unproblematic, the problem does not lie in these international standards per se, but in their enactment by those who misuse them in the name of democracy and freedom, and those who ignore or abuse them in the name of cultural identity. Moreover, human rights as international standards ought not to be sole instruments of action and change but one of a number of strategies for guarding and securing the wellbeing of people, other species and the planet, including those that are based on indigenous and other knowledge, faith or community ties. As such, a rights-based approach ought not to exclude other forms of solidarity or action nor reduce their imaginative space. A multitude of interdisciplinary and transdisciplinary strategies, knowledges, instruments and actions are needed if we are to build resilience and engender transformative action for adaptation and mitigation against climate change, within and outside schools (McKenzie et al., 2023). This includes indigenous knowledge systems and practices which have been neglected so far (Mbah et al., 2021; Williams, 2023). So, based on the arguments made, we contend that a rights-based approach to education about climate change and its health impacts in schools is a valid one, especially bearing in mind young people's vulnerability, issues of childhood and agency and intergenerational justice, but we maintain that it is one amongst a number of approaches for adaptation and mitigation.

Climate change does not just affect human rights that pertain to people's ontology or being, such as those related to the preservation and maintenance of life, it can also have an impact on other rights, such as the right to education and culture. Additionally, Resolution 10/4 states that the impacts of climate change "will be felt most acutely by those segments of the population that are already vulnerable owing to geography, gender, age, indigenous or minority status and disability" (https://www.un.org). By affecting vulnerable people the most, climate change can worsen the living conditions and human rights of people who may already suffer from human rights violations and further contribute to social injustice and inequality. Bearing this in mind, parties to the UNFCC and Kyoto Protocol adopted a set of decisions collectively known as the Cancun Agreements in December 2010 which emphasise "that Parties should, in all climate change-related actions, fully respect human rights" (CIEL, 2011, p. 5).

Children's rights are human rights too and will also be affected by climate change as described above. A further connection between children's rights and climate change impacts can be made through employing the UNCRC, "which is the most complete statement of children's rights ever produced and is the most widely ratified international human rights treaty in history" (https://www.unicef.org.uk). The UNCRC has 54 articles which list the civil, social, political, economic and cultural rights to which children are entitled and explain how adults and governments must ensure that all children enjoy all these rights (www.unicef.org.uk). Of particular relevance are Article 28 (right to education) and Article 24 (health and health services) which stipulates that "Every child has the right to the best possible health. Governments must provide good quality health care, clean water, nutritious food, and a clean environment and education on health and well-being so that children can stay healthy. Richer countries must help poorer countries achieve this" (www.ohchr.org). Moreover, Article 29 (goals of education) states that "education must develop every child's personality, talents and abilities to the full. It must encourage the child's respect for human rights, as well as respect for their parents, their own and other cultures, and the environment" (https://www.ohchr.org). Other UNCRC articles relevant to this argument include Article 1 (definition of the child), Article 3 (best interests of the child), Article 4 (implementation of the convention), Article 6 (life, survival and development), Article 12 (respect

for the views of the child), Article 13 (freedom of expression), Article 15 (freedom of association), Article 27 (adequate standard of living) and Article 42 (knowledge of rights).

A careful examination of these UNCRC articles not only demonstrates the link between children's rights and climate change impacts but allows for a further conclusion: children need to be taught about climate change and its health impacts in fulfilment of the highest possible achievement of their human rights. The CRC has declared that climate change "is one of the biggest threats to children's health and exacerbates health disparities. States should, therefore, put children's health concerns at the centre of their climate change adaptation and mitigation strategies" (https://www.ciel.org). It also "referred to climate change in its General Comment No. 20 on adolescence (2016) (paragraphs 2 and 12)" (https://www.ciel.org) and in September 2019, CRC joined with four other human rights treaty bodies (HRTBs) to adopt a landmark Joint Statement on Human Rights and Climate Change (https://www.ciel.org).

Within this context, Egypt has ratified many UN Human Rights Conventions, including the UNCRC, CEDAW (ratified in 1981), the ICCPR (in 1982) and the ICESCR (in 1982) and therefore has made binding international commitments to adhere to the standards stipulated in these human rights documents (www.claiminghumanrights.org). Egyptian citizens, including children, are able to invoke their human rights through these UN treaty bodies (www.claiminghumanrights.org). However, achieving the goal of human rights "depends upon the transformation of structures rather than the amelioration of states of affairs" (Bhaskar, 1991, p. 76). Again, education has a role in helping people transform their lives and exercise their agency for social change.

Employing Roy Bhaskar's critical realist arguments on "the dialectic of desire to freedom" (Bhaskar, 2008, p. 260), it can be maintained that education, both as a right and a freedom, has a role in absenting ills, such as those of climate change and its health impacts. By informing people, education can provide people with reasons or causes to exercise their agency "through the intentionality of praxis … shown in the capacity to transform the world" (Bhaskar, 2008, p. 259). Education can help people to act individually and collectively, develop their agentive freedom and autonomy and empower them to be free from constraints, such as ill health as an impact of climate change. An uneducated person cannot serve in their own government and an uneducated citizenry is unable to champion policies and practices that protect their rights.

All of the above-mentioned international declarations and resolutions recognise health as a universal human right and consider education to be one of the necessary approaches to achieving and maintaining this right. Within this context, Egypt, a founding member of the United Nations, has signed and ratified both the ICESCR and CRC and has actively participated in all international conferences including the Rio Earth Summit. Yet, a critical examination of the Egyptian school curriculum indicates that the country needs to do much more to translate words into action when it comes to health education in schools, especially that linked to the health impacts of climate change.

Methodology and Methods

A multi-level, multi-method, intensive critical realist methodology was employed (Bhaskar, 1993). There are several reasons for favouring a critical realist methodology. For a start, critical realism makes a key distinction between reality (ontology) and our knowledge of reality (epistemology) and vindicates being, which makes its especially supportive

to considerations of both human and post-human approaches to the environment. Bhaskar originally developed his thinking about critical realism for application to the natural sciences but this ontological-epistemological distinction is especially useful in the social sciences, including education (Khazem, 2018). Then there is the fact that critical realism has a particular focus on 'absence' – which will prove valuable below for considering why certain things are *not* taught. Within climate change education, this could be due to curricular absences or absences in teachers' subject knowledge, for example. In addition, the critical realist concept of 'the four-planar social being' is helpful for considering complicated ('wicked') socio-scientific issues in science education, as it asserts that social transactions take place around the four planes of the self, others, society and nature (Bhaskar, 1993). This is applied here both in the curriculum scrutiny and as a focus for interviews with teachers and students.

As a consequence of the overall aim of the study and the background literature, two research questions were posed:

- RQ1 What do 14–15-year-old Egyptian school children know about climate change and its health impacts?
- RQ2 How is climate change and its health impacts addressed in Egyptian state schools?

Interviews with school students were used to answer the first research question and interviews with teachers and a document analysis of the school curriculum for the second. The principal reason for using interviews is that they provide a versatile social research method which allows participants to explain in their own words how they understand and interpret the world around them (Knott et al., 2022). One-to-one semi-structured interviews were conducted, with slightly different interview schedules employed for students and for teachers. All interviews were conducted in Arabic by the first author, electronically recorded and transcribed. Document analysis contributed to answering the second research question as it helped reveal the intentions of the school curriculum. Both interviews and document analysis align well with critical realist methods of inquiry (O'Mahoney, 2016).

Sampling

Non-probability, purposive sampling was employed as it was anticipated that the number of interviews would be too small to be statistically representative (Knott et al., 2022). The first author's prior knowledge about the Egyptian school system, the difference in localities in relation to students' socio-economic background and the importance of place in terms of relations with nature helped determine the type and location of schools where data collection might take place. The actual schools were then selected accordingly, based on a search on the Egyptian Ministry of Education website (https://moe.gov.eg/ar).

The location of the schools was important, given the range of habits and environmental pressures in Egypt. Accordingly, schools from the capital Cairo, with its heat island effect, the Delta, with its rich agricultural land, and Alexandria, with its propensity for flooding and the threat of sea level rise, were selected. A mixture of schools in affluent areas and ones in areas of deprivation, as well as normal and additional English language schools, were chosen. In the end, the research sample constituted three schools in Cairo (C1, C2, C3), two schools in the Qalyubia Governorate in the Delta (D1, D2) and one school in Alexandria (A1). In all six schools, students participated in interviews at the discretion of the senior staff, so the selection of students was not controlled by us, although we indicated

to staff that in mixed schools the aim was to interview equal numbers of boys and girls, if possible. Science, geography and social studies teachers were interviewed as available and were selected by the headteacher who knew who was available on the day of the interview. In all, interviews were undertaken with 34 students (23 female, 11 male) aged 14–15 and seven teachers of science or geography (4 female, 3 male). Students came from schools as follows: (School C1, n = 6; School C2, n = 4; School C3, n = 4; School D1, n = 6; School D2, n = 7; and School A1, n = 7). Two teachers were interviewed from School C1 and one from each of the other five schools (C2, C3, D1, D2, A1).

The curriculum documents were purposively chosen to be the whole Egyptian school curriculum (both academic and vocational) for every subject, every year and for all terms each year. The documents were accessed electronically on the Egyptian Ministry of Education e-learning portal. Subjects for each phase (kindergarten (ages 3–5), primary (ages 5–11), intermediate (ages 12–15) and secondary (ages 16–18)) were selected by clicking on relevant e-syllabuses for each term.

Data analysis

Data generated through the interviews and document analysis were organised and examined through a critical realist lens, employing analytical frameworks which were developed for this purpose.

Students' answers to interview questions were organised broadly around the critical realist 'four-planar social being' concept, introduced above, which examines social transactions within the four planes of the self, others, society and nature. The critical realist notion of transformative praxis was employed to consider students' agency for praxis in relation to climate change and its impacts. Students' answers were further examined to determine knowledge absences, if any, in terms of misconceptions, gaps and omissions.

Data from the interviews with the science and geography teachers were organised thematically in a similar way to student data, again employing the critical realist notions of the four-planar social being, transformative praxis and absence. Understanding teachers' knowledge and the absence of knowledge was important to determine how such knowledge relates to students' knowledge about the topic.

Data generated through a scope and sequence qualitative document analysis of the Egyptian curriculum (both academic and vocational) with scrutiny of every subject and stage were analysed using a critical realist analytical framework. The whole curriculum was read page by page and data generated in the form of notes, detailing where (stage, subject, year, term) and how climate change was addressed in the school curriculum. The curriculum was combed by searching visually and reading all text and image captions to indicate the presence or absence of the specific terms: climate change (التغير المناخي), global warming (الانحباس الحراري) and greenhouse effect (البيت الزجاجي). These three terms were chosen as search terms because of their links to climate change but the whole curriculum was read as an electronic search facility was not available at the time.

Where these terms were found and how they were explained was noted in detail to check for any gaps, omissions or misconceptions. Reading the curriculum thoroughly also enabled notes to be made on any content related to nature/the environment, individual or collective responsibility and action to protect against damage, degradation or pollution, issues to do with consumption and waste, and other related content about the topic in any format, whether poetry, prose, number or image. A detailed description of content was included in

the analysis to explain how climate change and its impacts, particularly its health impacts, were addressed in the curriculum.

Ethical Considerations

The research was conducted in an ethical and culturally sensitive manner. Ethical approval was obtained from the Research Ethics Committee at the authors' university and fieldwork complied with the British Educational Research Association (BERA) guidelines in place at the time (BERA, 2011). Access was initially secured through the Central Security Bureau at the Ministry of Education in Cairo, then through the security officers and directors in the three local education authorities involved. Informed consent was obtained and participants were protected by pseudonymising them. Care was taken to protect participants from harm and safeguarding practices were employed with students. Attention was paid to data protection, storage and security and electronic materials were protected using encrypted passwords.

Findings

This section begins with the findings from the interviews with the students and then presents findings from the teacher interviews and the curriculum document analysis. It tries to identify any absences in students' knowledge about climate change and its health impacts. Measures to absent the absences or constraints (Bhaskar, 1993) that hinder Egyptian students' development of transformative knowledge, skills, attitudes and behaviours as well as agential actions in relation to climate change and its health impacts can then be proposed.

Students

Students' answers to questions about the health impacts of climate change demonstrated instances of valid knowledge but also many gaps and misconceptions. A common feature of students' answers was their conflation of the effects of air pollution on people's health with those of climate change and this was spread across all schools:

> Influenza and lung disease. (Mirna)
> Chest and respiratory diseases due to pollution. (Martina)

Even those students who had more elaborate answers confused the health impacts of climate change with those of air pollution, and there were several erroneous explanations:

> There will be an increase in death due to pollution when people breath harmful air. Newborn babies will be deformed due to nuclear reactors. (Farouq)

A significant number of students correctly identified the effects of heat exposure due to an increase in temperature as the most common health impact, and these instances were spread across all schools. Some linked this to increased energy consumption:

> An increase in temperature will cause disease and at home you will need to run air-conditioning for 10 hours. (Ahmad)

One student linked the effect of heat with population density (without referring to the heat island effect as a scientific term/concept):

> There will be an increase in temperature and the heat will be harmful, especially that Egyptians are stacked in one big mass like Cairo. (Farouq)

A few students mentioned the direct effect of heat on food and water availability but also had some misconceptions:

> Diseases will increase amongst old people, and some will die from heat. This happens in our village. Children will also suffer. Basic nutrition will be affected due to effect on crops. (Hanina)

Only one student accurately pinpointed the link between the effects of temperature increase and an increased need for health care, while still mentioning pollution:

> Climate change will lead to disease and makes human beings weak and incapable of doing things due to the high heat. There will be more need for health care and there will be more diseases that we cannot treat due to all this pollution. We need to find better things which work without causing damage to the environment, such as solar power and hydraulic energy. (Ahmed)

Some students talked about water pollution without explaining how climate change can cause this, for example through flooding, and their answers showed omissions and misconceptions:

> It will impact water. There will be rubbish in the water. It will also cause lung cancer, kidney failure, stomach ailments and colds and influenza. (Mana)

One student talked about climate change causing epidemics but gave a mistaken example:

> All living organisms will be affected. There will be diseases such as colds, and epidemics such as Ebola. (Omar)

And one student maintained that climate change is an environmental problem and does not affect human health:

> It does not affect human beings, only the environment. (Khaled)

When asked about other impacts of climate change, students seemed mostly to list negative impacts on (non-human) animals, plants and the physical environment; it was telling that several mentioned polar bears rather than Egyptian fauna and flora or, for example, Red Sea corals:

> It affects animals such as the polar bear, because ice melts and it cannot cope. There will be floods because of ice melting in the poles. (Nourhan)
> Some animals such as polar bears may die and become extinct. Plants cannot tolerate an increase in heat and crop yield will suffer. The economy will weaken, and basic foods will suffer. (Hanina)

One student suggested some positive impacts on plants, such as a favourable effect on heat-loving crops:

> Rain is goodness and plants will be affected by heat. Sunflowers love the heat though. (Omar)

Another suggested negative impacts on other crops:

> Oranges are a winter crop in Egypt. If temperatures increase, we won't be able to grow winter crops well anymore because already the winter season is short. (Ahmad)

Students were clearly much more confident in listing effects on the physical environment. However, their answers showed misconceptions too. Interestingly, they did not display signs of anxiety about what they said, although some used language that predicted a grim future:

> It will increase the temperature of the planet, volcanoes will explode, animals will die, the ozone hole will widen and become bigger than California, and as the ozone layer becomes bigger, ultraviolet rays will cause many diseases. (Mahmoud)

Similarly to the conflations maintained about the impacts of climate change and those of pollution on health, there seemed to be confusion related to pollution regarding other impacts of climate change:

> Plants will die, or get irritated, water shortages will become prevalent and emissions from factories will lead to acid rain. (Mahmoud)

Teachers

When asked about the health impacts of climate change, these Egyptian teachers' responses demonstrated quite a lot of valid knowledge but also some serious misconceptions. It was noticeable that there was some confusion between the health impacts of climate change and the health impacts of other types of air pollution, as also seen with students:

> Pollution affects people's health in general and an increase in temperature accompanied with an increase in carbon dioxide levels in the atmosphere will cause people to feel asphyxiated and affect their psychological state. Most of the human body systems and its functions will be affected and people will feel lazy and lethargic. (Jamal)
> Carbon dioxide is a major air pollutant and as a result it causes lung cancer and other chest allergies. Car exhaust fumes, factory smoke and cigarettes smoke don't help either and only solar power and hydroelectric power would have no health impacts. Currently, we get too much smoke everywhere and life becomes shambolic as a result. (Sayed)
> Climate change will of course lead to health impacts. Exhaust fumes cause chest allergies; cancer diseases will increase and so will ailments of the liver and kidneys. (Najwa)

For some teachers, the impacts were both minimal and confused:

> Climate change has negative impacts on health because it may affect people's mood and therefore their productivity and ability to work, and the poor classes might suffer more from winter illnesses such as influenza. We already have negative health impacts due to the weather because of the seasonal dry, spring *Khamaseen* winds. (Imad)

Only one teacher mentioned heat-related tropical diseases:

> There will be an increase in diseases due to the increase in temperature, including some tropical diseases. (Manar)

And only one out of the seven teachers, a social studies teacher, managed to pinpoint any health impacts of climate change related to the determinants of health:

> There will be water scarcity, and drought will be a fundamental problem which will lead to food shortages. There will be an increase in the spread of certain diseases such as new viruses. (Sayed)

When asked about other, non-health related impacts of climate change, Sayed felt there would be some positive as well as negative impacts:

> There will be some positive impacts such as an increase in plant diversity because any climate change will affect plants. However, there will be negative impacts because hotter weather will affect people's productivity and therefore Egyptian Gross National Product, and there will other environmental impacts such as flash floods and flooding such as what happened to houses which got destroyed by a flash flood in Aswan. If temperatures increase too much this will affect plant growth and crop yield will reduce. It will affect people, animals and plants. (Sayed)

By comparison, Manar, a science teacher, had a more succinct but more accurate answer:

> There will be an effect on organisms which prefer colder climates, and they may become extinct. Ice will melt so sea water volume will increase which will lead to sea level rises in seas and oceans; this will inundate coasts and cause erosions, as is happening to the concrete sea barriers on Alexandria's coast. (Manar)

Jamal added an example from his personal experience:

> Impacts may include drought waves, the melting of ice in the North and South poles, sea level rises and the inundation of land. I am from the countryside and the area where I come from is known for crop production. Many crops and agriculture in general will be affected by droughts. (Jamal)

Sayed was more geographically oriented in his answers:

> Coasts will erode because rivers are not flooding, so coasts are not replenished which will increase erosion and loss. Coasts will drown under water because of the melting of ice due to temperature increases. There will be a gradual disappearance of wildlife, seasonal migration of birds will be affected, and natural plant cover will become scarcer. (Sayed)

Najwa had a brief answer:

> It will affect crops; it is all an endless circle. (Najwa)

Shaima is a secondary science teacher, but her answer could have been more accurate:

> There will be an acute increase in temperature. Many organisms will not be able to cope and will become extinct and be lost to us. I don't think rain will be affected. The weather was not like this before. Summer is now hotter, and winter is colder. (Shaima)

Finally, Afaf focused on one impact relevant to her environment:

> Melting will increase in the two poles which will lead to a rise in sea water levels. I showed this to the students on a map on the computer. The poles are open on the

ocean and that melting will cause rising in the ocean and seas and cause a threat of flooding like in Alexandria where the city might drown. (Afaf)

As can be seen from these answers, impacts of climate change unrelated to health were, as one would expect, better understood by the teachers than they were by the students, but there was still inconsistency, lack of depth and lack of accuracy.

Vocational Curriculum

Climate change and its related terms are completely absent in all three years and four subjects (agriculture, business studies, hotel and tourism services and industrial studies) of the vocational curriculum. This is a stark finding, bearing in mind that these vocational subjects provide ample opportunities for consideration of climate change and its health impacts. As an example of such missed opportunities, a succinct analysis of the first-year curriculum (for 16-year-olds) of the agriculture vocational programme is provided in Table 1.

As can be seen from Table 1, there are many possible links to climate change and Eco-Health which are absent in these vocational topics. Water availability impacted by climate change will affect water availability for food production, both in terms of crop production and farm livestock, as well as drinking water, which has health impacts. The rising cost of water will affect poor people and has an impact on their health, while sewage dumping without treatment in the River Nile reduces drinking water quality, impacts fish and other organisms and has an impact on human health both through contact with polluted water or bioaccumulation of harmful chemicals in ingested fish.

Academic Curriculum

Analysis of the academic school curriculum, which covers all school phases and subjects, shows that the terms ‘climate change’, ‘global warming’ and ‘greenhouse effect’ appear interchangeably in only eleven lessons: once in the primary phase, three times in the

Table 1 Climate change in the first-year agriculture vocational curriculum (for 16-year-olds) in Egyptian schools

Topic	Climate Change Presence/ Absence
Field Product Foundations: includes the importance of water conservation in irrigation	Absence
Islamic Education: discusses agriculture in Islam	Absence
Agricultural Industries	Absence
Field Crops: discusses the importance of climatic temperature and water in yield production	Absence
Area and Irrigation: a whole section on water sources for irrigation and solutions for water scarcity, desalinisation, sewage treatment, re-using extra irrigation water, etc	Absence
Biology	Absence
Chemistry	Absence
Physics	Absence
Computing	Absence

intermediate phase and seven times in the secondary phase. Bearing in mind that many Egyptian students stop attending school at the end of the intermediate phase and instead attend private study to cram for examinations at age 18, this is a disheartening finding. Table 2 maps the presence of climate change and related terms in the Egyptian academic school curriculum.

The curriculum absences are magnified because there were many missed opportunities where climate change and its health impacts could have been included within the Egyptian academic school curriculum. The term 'climate change' does not appear in the curriculum until the secondary phase and then only a few times, an unexpected finding, especially as most of the detailed content to do with climate change is in the first year of secondary schooling in both chemistry and geography curricula. In secondary years 2 and 3, climate change and its related terms appear in the English curriculum only. It is also notable that there is no mention of Egypt in terms of impacts or any mention of effects on human health except within the geography curriculum, in Unit 3 on 'Climate, Fauna and Flora in Egypt', which includes lesson 2: 'Climatic Regions in Egypt and the Impact of Climate Change'. This lesson mentions the possible drowning of large sections of the Northern Coast and the Delta. It also mentions increased evaporation, a possible reduction in Nile water and changes in the amount and times of precipitation. The lesson lists impacts of climate change on energy production and consumption because of an increased need for air-conditioning and less water available for hydroelectric power. It also mentions the resulting effect of dry weather in increasing Saharan dust, which reduces the shelf life of air-conditioning units and other electrical items – but without mentioning people. This lesson is also the first instance when the health impacts of climate change are mentioned, to include spread of serious diseases like malaria and increases in skin cancer, sunstroke and insects that carry diseases. It is also the first instance that the impacts of climate change on Egyptian tourism are mentioned – more dust in air leads to pollution and fewer tourists wanting to visit – without mentioning how this impacts local people. Disappearance of sections of the Northern Coast, where tourist resorts are located, and loss of corals, which attract Red Sea tourism, are mentioned. This lesson is also the first instance where the impacts of climate change on Egyptian agriculture are identified: a reduction in winter crops which need lower temperatures, though summer crops may increase in yield, increased need for irrigation and an increase in desertification. Finally, the secondary year 2 English curriculum includes Unit 18, 'Global Issues', which mentions homelessness as an impact of flooding due to sea level rises. The only occasion where climate change or related terms appear in

Table 2 Climate change and related terms in the Egyptian academic school curriculum

Stage	Absence/Presence and year	Subject	Scientific term used
Primary	Presence, year 6	Science	Greenhouse effect
Intermediate	Presence, year 1	Science	Greenhouse effect, Greenhouse gases
Intermediate	Presence, year 1	Social studies	Global warming, Greenhouse gases
Intermediate	Presence, year 2	Science	Global warming, Greenhouse effect
Secondary	Presence, year 1	Chemistry	Global warming, Climate change
Secondary	Presence, year 1	Geography	Greenhouse effect, Global warming
Secondary	Presence, year 2	English	Climate change, Greenhouse effect, Global warming
Secondary	Presence year 3	English	Climate change, Global warming

the Egyptian secondary year 3 curriculum is also in the English curriculum in Unit 9, 'The Power of Nature', which has no mention of health impacts.

Discussion and Conclusion

Limitations of the study included limited time to collect data due to bureaucratic delays in issuing official permissions to access schools and a paucity of existing research on this topic in Egypt. Future research could overcome these shortcomings, in part by building on this study. There would be considerable value in seeing how the Egyptian curriculum is addressing the climate emergency and determining whether teachers become better equipped to teach EcoHealth.

As can be seen from the findings, while some students were able to manifest some understanding of climate change impacts, including those with implications for human health, and the health of other organisms, many students got confused between the impacts of climate change on health and the direct impacts of other types of air pollution on health. Impacts on other species, and how such impacts might affect human health, were mentioned by few students, and with little detail. Only one student mentioned the impact of climate change on health services. It is a cause for concern that not a single student was able to identify a rise in malaria as a possible health impact of climate change. Anthropogenic climate change poses a risk in terms of the extension of malarial zones, and resurgences have occurred in the Fayoum region and other areas since 2014 (Abdelsattar & Hassan, 2021).

Teacher understandings of the health impacts of climate change were, as one would expect, better than those of students. Nevertheless, given the serious and varied health impacts of climate change that can affect Egyptians, it is a cause for concern that teachers were typically not very aware of many of these impacts. Teachers are therefore unlikely to alert students, increase their understanding and support their agency in ways that can promote their health and wellbeing or enhance any mitigation or adaptation. When asked about the non-health impacts of climate change, teachers were more confident, detailed and accurate in their responses, though some absences and misconceptions were still detected.

The shortcomings in both teachers' and students' understandings of the health consequences of climate change make sense when the Egyptian school curriculum is analysed. Not only is there remarkably little about climate change in the school curriculum, and correspondingly even less about the health consequences, what there is is oddly spread across phases, subjects and years. There are many missed opportunities across the whole curriculum. More generally, the critical realist framing of the analysis reveals there is little evidence that schools are preparing the next generation with the knowledge, the capacity for agency and the dispositions to tackle the many problems that Egypt faces or to take advantage of the opportunities it affords. Good curricula can help both teachers and students (e.g., Fensham, 2022).

There is a growing literature on climate change education and on the contribution that school science can make to this. In a systematic review of effective climate change education, Monroe et al. (2017) identified the value of: (1) engaging in deliberative discussions, (2) interacting with scientists, (3) addressing misconceptions, and (4) implementing school or community projects. It needs to be admitted that globally, not just in Egypt, these pedagogical approaches are rarely found in schools. Effective pedagogy is greatly helped by an appropriate

curriculum. Chang and Pascua (2017) provide an analysis of the role of policy in the inclusion of the topic of climate change in the curriculum of school subjects in Singapore.

In terms of a critical realist framing, the absences in Egyptian schools, both in terms of curriculum and pedagogy, are notable, with absences in teacher understanding no doubt following, at least in part, from absences in the curriculum, and absences in student understanding similarly following, at least in part, from absences in teacher understanding. Absence can be causal because absences limit students' learning and therefore their capacity for individual and collective action against climate change. The critical realist concept of 'the four-planar social being', with its understanding that social transactions take place around the four planes of the self, others, society and nature, means that in some respects school geography education, which has both a human and a physical component, is more naturally suited than traditional school science education to address the complications of climate change, in particular the interactions between the levels at which it and its consequences operate.

In conclusion, school science education needs to change its aims, content and pedagogies if it is to prepare students for the challenges of the Anthropocene. While the importance of climate change is increasingly acknowledged, though disputed by a vocal minority (Kovaka, 2021), the health consequences of anthropogenic climate change are less appreciated. If school science education is to contribute to helping students develop an understanding both of Eco-Health and of human (and perhaps non-human) rights, it may need to move towards more of a Vision III framework than a Vision I or even Vision II one. Such a movement would facilitate an eventual response by citizens in Egypt and elsewhere to the many environmental problems that each country faces. In any event, while we would argue that there is much to commend a Vision III science education, we need in schools, in Egypt and in other countries, a curriculum and confident informed teachers that can foster hope, creativity and innovation in the face of environmental decline and future uncertainties (cf. Cheung, 2024). It has been shown that teacher knowledge and confidence can improve teaching about SSI (e.g., Lee, 2022). When it comes to the health impacts of anthropogenic climate change, the promotion of EcoHealth can help students to attain a good scientific understanding, to develop their agency and to flourish more generally.

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Declarations

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