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Education as Critical Infrastructure in the Anthropocene: An Anthropological Transition

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Abstract: This paper examines the transition to the Anthropocene as a significant anthropological change that challenges current approaches to understanding human agency, responsibility, and societal change. It argues that existing models of individual, organisational, and societal transitions do not adequately address the complexities of this new epoch, characterised by unprecedented ecological risks and interconnectedness. Drawing on the literature on the Anthropocene, transitions theory, EU conceptualisations of critical infrastructures, and recent work on emergent and relational infrastructures, this study develops a conceptual argument that recognises education as a critical infrastructure and schools as critical entities fostering community awareness and resilience. The practical value of this argument is that, by integrating environmental and social justice concerns, education can help stakeholders navigate the Anthropocene, including its colonial legacies. Ultimately, the paper calls for a reimagining of education and anthropology to cultivate new ethics of care, responsibility, and plural worldviews necessary for sustaining both human and more-than-human futures.

Keywords: Anthropocene, anthropology, education, transition, critical entity, crisis management, ethics.

Introduction

The Anthropocene, introduced by Crutzen and Stoermer in 2001 (Benner et al., 2021) as a term for a new geological epoch, is regarded as a human-dominated geological era (Leinfelder, 2013), marked by a clear ecological overshoot by humanity (Chakrabarty, 2015), which has profound negative impacts on Earth (Shrivastava et al., 2019), threatening the planet's sustainability (Lewis & Maslin, 2015) and the survival of other species (Dalby, 2016; Dominey-Howes, 2018). The Anthropocene is the epoch in which the human species has become, for the first time in geological history, a planetary-scale force (Dominey-Howes, 2018) and possesses full knowledge of the impact of its activities on the planet (Steffen et al., 2011).

However, although there is extensive scholarship on transitions at the individual, organisational, and societal levels, the implications of the transition to the Anthropocene – particularly regarding infrastructure, roles, and challenges – have not yet been fully explored. This lack of analytical tools becomes apparent when considered in relation to new risks and dangers that fundamentally challenge the assumption of a stable and recognisable world (Jennings & Dooley, 2007; Olsen et al., 2007), as well as less transparent and identifiable threats (Le Coze, 2018), which highlight the limitations of prediction- and anticipation-based data (Haste & Chopra, 2020) and raise concerns about the adaptability of previous models of crisis management to the current context (By, 2021). Moreover, education also appears to face uncertainties. The OECD (2020) report states that we are experiencing 'an unprecedented situation of great uncertainty about how to develop better schools', and Dishon and Gilead (2021) emphasise the remarkable lack of agreement about the goals of education.

The question that arises in this context is whether this transition and these uncertainties indicate new roles that education must assume. To address this question, this paper presents a conceptual argument based on two pillars. First, through its literature review, it argues that the transition to the Anthropocene represents an anthropological shift that existing analytical frameworks on individual, organisational, and societal transitions do not address. Second, in light of the recent shift in the literature from structural to emergent and relational types of infrastructure, this paper contends that education should be recognised as critical infrastructure. In this context, individual schools would operate as critical entities supporting students, parents, and local communities in the transition to the Anthropocene.

The remainder of this paper is organised in two parts. The first part provides an overview of the main reasons why the Anthropocene constitutes an anthropological transition, followed by a description of the main types of transition documented in the relevant literature. The second part, after presenting the evolution in the conceptualisation of critical infrastructures, discusses the new role that education is expected to play as a critical infrastructure in the Anthropocene. The final section examines individual schools as critical entities in fostering community awareness and development, and in promoting an ethics of care.

Literature Review and Methodology

This conceptual paper primarily employs a literature-based, argumentative methodology to identify the gap and develop its conceptual approach. Specifically, it draws on literature concerning the Anthropocene, transitions theory, EU conceptualisations of critical infrastructure, and recent work on emergent and relational infrastructures to identify the gap and frame the research question.

Anthropocene marks an anthropological transition.

The Anthropocene challenges anthropology by compelling the discipline to reconsider the "anthropos," or human subject, it studies (Ceballos et al., 2015; Haraway et al., 2016). Beyond marking a geological transition, the Anthropocene signifies a profound anthropological shift, positioning humans as a

geological force (Cernilo, 2023), transforming notions of agency and responsibility in contemporary life, and shaping both the symbolic and material realities of Anthropocene spaces (Moore, 2015). It generates new social imaginaries (Chakrabarty, 2016a, 2016b), influences chronopolitics (Chakrabarty, 2021), creates new spatial and temporal scales, and imposes new forms of coloniality (Valentine & Hassoun, 2019; Banerjee & Arjaliès, 2021). In this context, Latour (2013, p. 77) emphasised that the Anthropocene is 'the most decisive philosophical, religious, anthropological and political concept yet produced', challenging established categories of meaning, the limits of human action, and imposing new spatial and temporal realities. Accordingly, the transition to the Anthropocene underscores the need for new ethics and a new social contract (Leinfelder, 2013), improved decision-making about the future (Costanza et al., 2012), new economic principles and modifications to current stakeholder theory (Shrivastava et al., 2019), novel epistemic foundations, and a fundamental rethinking and reinvention of politics (Norbert et al., 2017).

The emergence of new types of threats and risks further highlights the anthropological dimension of the transition to the Anthropocene. Le Coze (2018) observed that we have moved from socio-technical risks, which concern large technical systems and describe failures that expose employees, the surrounding population, or passengers to hazardous processes, to globalisation and systemic risks, which relate to critical infrastructure and represent a standard approach to addressing safety problems in a globalised world, and subsequently to the Anthropocene, transhumanism, and existential risks, which refer to artificial risks resulting in planetary threats affecting all of humanity and its creations in their entirety (cosmo-bio-eco-techno-socio sphere, global3). The distinctiveness of risks and threats associated with the Anthropocene lies in the definition of 'Anthropocene risk' as risks arising from human-induced processes interacting with global social–ecological connectivity and exhibiting complex, cross-scale relationships (Keys et al., 2019). Anthropocene risks are linked to global environmental changes, which threaten human health and well-being, require urgent action (Haines & Scheelbeek, 2020; Tang et al., 2022), and are typically interconnected and driven by multiple factors (Tang et al., 2022), such as climate change, biosphere degradation, and human health crises (Steffen et al., 2015), and therefore should not be treated as isolated problems (Tang et al., 2022).

The anthropological framing of the Anthropocene aligns with Moore's (2016) concept of "Anthropocene anthropology," which emphasises an anthropological awareness of the Anthropocene as a historically contingent manifestation of social, political, and material processes, rather than uncritically accepting prevailing framings of the problem and its responses. Mathews (2020) argued that, rather than viewing the Anthropocene strictly as a geological epoch, anthropologists often approach it as a problem or lens that draws them into new forms of observation, analysis, and collaboration beyond traditional disciplinary boundaries. This anthropological shift towards the Anthropocene encourages consideration of transitions in time, space, agency, and responsibility, illuminating the lived realities and futures shaped by global environmental change.

Transitions

As described above, the Anthropocene represents an anthropological transition, a multidimensional process of change involving transformations in human social life, cultural practices, and their interrelations with the environment. These changes occur across various temporal and spatial scales and encompass political, ecological, and ethical aspects. However, scholarship on transitions to date has focused on three broad categories: individual, organisational, and societal.

At the individual level, transitions are dynamic, multidimensional, and often overlapping processes triggered by critical events and changes in individuals or their environment, marking a shift from one relatively stable state to another (Meleis, 2010, p. 11). Meleis and Trangenstein (2010) identify four types of transitions at the individual level: a) individual developmental transitions, referring to stages of growth

and development in an individual's life cycle, such as the transitions from childhood to adolescence, adulthood, and old age; b) family developmental transitions, referring to changes in which individuals in a pre-existing role constellation are added or removed, such as the transition from non-parenting to parenting status or from single to married status; c) situational transitions, involving a change in occupational role and status or triggered by events that require spatial or geographical changes, such as relocation or migration; and d) health/illness transitions, referring to the recovery process, the diagnosis of a chronic illness, and similar experiences.

At the organisational level, transition refers to a nonlinear change from one dynamic equilibrium to another (Loorbach et al., 2017). Organisational transitions represent changes in the environment, triggered by broader social, political, and economic factors, or by intra-organisational shifts in structural dynamics (Schumacher & Meleis, 2010, p. 40), including changes in leadership and the implementation of new policies and practices.

At the societal level, societal transitions refer to structural and systemic changes in a stable societal system towards a new dynamic equilibrium that develops over decades or generations (Geels & Schot, 2007; Grin et al., 2010; Kanger & Schot, 2019). Early studies described societal transitions as 'multi-level' (Rip & Kemp, 1998) or 'multi-phase' (Rotmans et al., 2001) processes. However, Loorbach et al. (2017) argued that societal transitions can be represented as an X-curve, with interactions between breakdown and build-up patterns. Sustainability transitions, a subcategory of societal transitions, are defined as large-scale societal changes considered necessary to address 'grand societal challenges' and are characterised by non-linearity, multilevel dynamics, co-evolution, emergence, variation, and selection (Loorbach et al., 2017). In relation to societal transitions, Kanger and Schot (2019) argued that over the last 150–200 years we have been in a transitional phase, facing the twin challenges of environmental degradation and social inequality, and introduced the concept of the Deep Transition Framework to outline the need for a wide range of socio-technical systems to provide transport, energy, food, housing, health, and communications.

The transitions described above all involve a shift from one relatively stable state or dynamic equilibrium to another, triggered by critical events or changes at the personal level (such as developmental stages, role changes, or health status), organisational changes (such as leadership shifts or new policies), or societal shifts (such as structural and systemic changes over decades or generations). What is missing from the discussion above is an explicit reference to broader anthropological changes, such as the Anthropocene. Furthermore, the types and patterns of transitions mentioned do not explicitly address the mechanisms or strategies that facilitate successful transitions at all levels, such as coping strategies at the individual level or change management practices at the organisational level, which may also be reflected at the societal level.

To address these gaps, the following section will examine how integrating critical infrastructures into the framework could provide a clearer understanding of the types of infrastructure that can facilitate, and are required for, the anthropological transition to the Anthropocene.

Critical infrastructures, critical entities and relational infrastructures

The changing nature of risks and threats in the Anthropocene highlights the need to reconsider which critical infrastructures should be identified, managed, and maintained to ensure societal resilience and security. This section reviews EU directives and relevant literature on critical infrastructures to map conceptual shifts in the mechanisms required for this process.

The EU perspective

According to Council Directive 2008/114/EC (Articles 2 and 3), '"critical infrastructure" means an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, or the economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions'. Under the 2008 Council Directive, ECIs are limited to two sectors: energy and transport. The energy sector consists of three subsectors: electricity, oil, and gas, while the transport sector comprises five subsectors: road, rail, air, inland waterways, and ocean and short-sea shipping and ports. The significance of these ECIs' impacts was assessed against various overarching criteria, including accidents, economic and environmental impacts, and public impacts.

Almost ten years after the initial definition, the first evaluation report of the European Commission (2019) concluded in 2019 that 'the technological, economic, social, policy/political and environmental context in which critical infrastructure in Europe operates has changed considerably since the Directive entered into force. Because of these changes and the challenges they pose to CI operations and security, the directive has partial relevance. Following the evaluation report, the European Parliament and Council presented a proposal for a Directive on the resilience of critical entities (COM (2020) 829), which differs from Council Directive 2008/114/EC in two main respects.

First, the focus shifts from an asset-based, all-hazards approach to critical infrastructure protection – which covers both artificial and technological threats as well as natural disasters – to a systems approach centred on resilience. The new proposal emphasises the resilience of critical facilities and states that entities providing essential services must be resilient; that is, able to resist, absorb, accommodate, and recover from incidents that could cause serious, potentially cross-sectoral and cross-border disruptions. This shift aims to address the current and anticipated risk landscape more effectively, the increasingly close interdependencies between sectors, and the growing interdependencies between physical and digital infrastructures (COM (2020) 829 final). Second, although the scope of critical infrastructure in the 2008 directive was limited to energy and transport, the 2020 proposal by the European Parliament and the Council extended the scope to additional sectors such as banking, financial market infrastructure, health, drinking water, wastewater, digital infrastructure, public administration, and space, alongside energy and transport.

Moreover, the newest CER Directive of the European Parliament and the Council (2022/2557 (CER) is the latest relevant directive focusing on organisations providing essential services. It covers the following eleven sectors: energy, transport, banking, financial markets, health, drinking water, wastewater, digital infrastructure, ICT service management, space, and public administration. Its main difference from previous EU directives is that it is resilience-oriented. While the 2008 directive was infrastructure-centric and focused on European critical infrastructures with significant cross-border impact, the 2022 directive (Directive 2022/2557) is entity-centric. It establishes a comprehensive resilience framework for critical entities across multiple sectors within the internal market and is not limited to cross-border infrastructure.

The CER Directive shifts the focus from the concept of critical infrastructure, which referred to physical assets, systems, or components essential for vital societal functions and concentrated on their identification and protection, to the concept of critical entities. Critical entities are the operators or providers of essential services that use or manage such infrastructure and are responsible for ensuring the resilience of these services, subject to broader resilience requirements. This resilience-based approach reflects a broader shift in EU security thinking, recognising that in an interconnected world, it is impossible to prevent all disruptions to critical infrastructure, and that the focus must therefore be on ensuring systems can absorb and recover from shocks.

In summary, the transition from protecting critical infrastructure to ensuring the resilience of critical entities marks a significant evolution in EU policy. The CER Directive's emphasis on resilience against "natural hazards, terrorist attacks, insider threats, or sabotage" reflects this heightened threat awareness. The Directive explicitly acknowledges that critical entities face threats from "deliberate, accidental, natural or hybrid" sources, reflecting the EU's growing concern about hybrid warfare and state-sponsored attacks on critical infrastructure.

However, despite these shifts, two important limitations persist. First, the framing, although expanded, remains narrow, focusing on technical systems, material forms, and physical networks, without including education as critical infrastructure. Second, although awareness now encompasses more threats and dangers, the anthropological transition to the Anthropocene, the resulting new dangers and threats, and the unprecedented levels of interconnectedness and interdependence have not been addressed.

The infrastructural turn

Contrary to the narrow framing of infrastructure above, recent decades have seen a shift in focus from the material, physical, and technical dimensions of infrastructure to its relational attributes. Scholarship highlights that infrastructure is not a technical or structural property, but primarily a relational property that emerges for people in practice and is associated with activities and structures within a particular cultural context (Star & Ruhleder, 1994). Hopkins and Woulfin (2015) also emphasised the relational nature of infrastructure, stating that infrastructure is not a fixed scaffold or support that fades into the background, but emerges only when constructed, worked on, and used in teaching and leadership practices (pp. 375–376). Roe and Schulman (2018) highlighted this relational dimension of infrastructure, distinguishing between planned and emergent infrastructure. According to the authors, emergent infrastructure implies 'a relational perspective that aims to show how people, organisations, and related technical systems relate to each other through infrastructure design processes'. The authors also argue that the focus should be on how practitioners with different perspectives collaborate, rather than on structural coordination challenges.

Similarly, Greenberg et al. (2020) emphasise the relational dimension by introducing 'community infrastructuring', which broadens the definition of infrastructure and challenges the dominance of those who originally built the structures of practice and interaction. 'Community infrastructuring' creates new opportunities for a) recognising the resourcefulness of communities and b) accounting for permeability, movement, and transformation in ways that enable democratised action, redistribution, and the redesign and restructuring of systems towards the ideals of restorative justice. It describes situations where a community collectively engages in redistributing resources, developing new resources and knowledge, and creating new, critically informed, and healing forms of infrastructure (such as education and knowledge exchange, food production, and distribution). This process establishes conditions that support community members to organise innovatively to address injustices.

Thus, the infrastructure turn refers to a significant shift over the past two decades, in which infrastructure is no longer seen solely as physical constructions or technical systems, but as a broader conceptual framework for exploring how infrastructures create regional imaginaries and influence lived experiences, often in gendered, racialised, and classed ways (Addie et al., 2020). It highlights the emotional, cultural, and social dimensions of infrastructural consumption (Graham & Marvin, 2022) and helps to explain historical change and interconnections driven by power dynamics, frictions, and inequalities (Bridges, 2023). This infrastructure turn, by moving beyond technical, material, and spatial artefacts, illuminates how people, through their interactions, lived experiences, embodied practices, and surrounding cultures, create relational infrastructures.

Results

The previous section has established (1) that the Anthropocene represents a profound anthropological shift, which existing transition models focusing on individual, organizational, and societal transitions fail to address adequately due to its unique complexities; (2) that education is diachronically absent from EU conceptualizations of critical infrastructures; and (3) that recent trends in the literature underscore the emergence of new types of infrastructure, moving from purely infrastructural assets to emergent and relational properties that are better suited to address new threats and needs.

Discussion

Having established the need to broaden and reconceptualise the understanding of critical infrastructure to include education, and to address this paper's research question, the discussion calls for reimagining and reinventing the connections between education and anthropology in two directions. First, by including education among critical infrastructures, and second, by conceptualising individual schools as critical entities in this context.

Education as critical infrastructure

Despite the infrastructure turn, education is an essential component of critical infrastructure – supporting key societal functions by nurturing and preparing future citizens and serving as a crucial element for societal continuity and resilience – yet education, as a system, is still not considered critical infrastructure. This paper argues that education should be recognised as a critical infrastructure and that schools should be recognised as critical entities. This argument rests on two pillars.

The first pillar draws on the unprecedented levels of interconnectivity and interdependence brought about by the Anthropocene. The experience of recent financial, refugee, health, and energy crises has made it clear that 'today's threats recognise no national boundaries, are connected, and must be addressed at the global and regional as well as the national level' (United Nations, 2004, p. 1). We live in an era of interconnected systems and stakeholders (Setola et al., 2009), where the world itself is interconnected, with many local events causing ripple effects globally and global changes having localised impacts (Le Coze, 2018). Regarding interdependence, scholars have repeatedly emphasised that the technological thrust of globalisation increases the interconnectivity and interdependence of systems (Helbing, 2013), to the extent that the resilience of one system depends on the degree of resilience of another (Katina et al., 2014). More recently, Mikellidou et al. (2018) highlighted that modern infrastructure functions as a 'system of systems', with numerous interactions, interconnections, and interdependencies that can have cascading effects on other systems in the event of failure (Frykmer et al., 2018).

The second pillar refers to new forms of coloniality and inequality imposed by the Anthropocene. Tsing et al. (2019) introduced the term "patchy Anthropocene" to emphasise that the Anthropocene is not homogeneous but comprises diverse, uneven patches in which human and more-than-human histories, politics, and ecologies intersect and evolve in specific ways. Similarly, Rosengren et al. (2023) highlighted that the Anthropocene narrative reflects the "coloniality of reality", as it tends to universalise humanity as a homogeneous agent responsible for climate change, which obscures global material inequalities and power asymmetries – many rooted in colonial histories and ongoing colonial relations. Likewise, Smith et al. (2025) emphasised that colonialism and the Anthropocene are intertwined, with the environmental crisis of the Anthropocene being deeply shaped by colonial histories of exploitation and power imbalances. This narrative can obscure the unequal racial, economic, and geopolitical relations that underpin both environmental degradation and the social realities of climate change, which have created environmental conditions that now disproportionately threaten marginalised communities and developing states.

From both perspectives, the role of education as critical infrastructure is, on the one hand, to help students, parents, and local communities prepare for and become aware of the new scale crisis dynamics imposed by the Anthropocene, and on the other, to integrate environmental and social justice concerns by helping them understand how environmental degradation is entangled with histories of exploitation, displacement, and colonialism.

Schools as critical entities

Envisaging schools as critical entities builds on a multi-actor model (Avelino & Wittmayer, 2015) involving students, families, and the public, and empowers micro-level actors with a shared transition narrative and agenda (Loorbach, 2010). Furthermore, establishing schools as critical entities at the micro level aligns with the need for bottom-up approaches to ensure engagement, relevance, acceptability, and sustainability for individuals and communities (WHO, 2022; European Parliament and Council of the European Union, 2020). In alignment with the dual role of education as critical infrastructure, schools' role as critical entities is first to foster community awareness and development in response to the challenges posed by the Anthropocene, and second to engage with new ethics of care, responsibility, and accountability.

The argument that schools should foster community awareness and development aligns with scholars and policymakers who emphasise that young people must be included in communication strategies during crises (Mintbust et al., 2018), as they are essential partners in achieving sustainable economic and social development and in finding innovative solutions to the challenges faced by countries and communities. Conversely, scholars have noted that previous crises have shown citizens themselves are a source of broad resilience by taking action to protect and care for others (Kruke, 2015; Bergström, 2018). The proactive role of citizens in crisis management is of paramount importance, as those who know their community can share that knowledge as a significant contribution to crisis prevention and management (Koch et al., 2017). Furthermore, citizens should be involved in resilience building, as their participation influences the effectiveness of crisis prevention, response, and recovery (Marana et al., 2018). This indicates the need to rethink critical infrastructures from a community-based perspective.

The second objective of schools as critical entities is to establish new ethics of care, responsibility, and accountability. As mentioned above, the Anthropocene raises new ethical and political questions about human responsibility and accountability in shaping viable ways of living on Earth. Schools are crucial in this process, as they play a vital role in helping students, parents, and local communities understand and shape human–environment relations in a changing world, and in examining how humans are implicated in and respond to these global transformations.

Regarding this objective, Valentine and Hassoun (2019) have emphasised that the Anthropocene radically extends the scale of agency and futures beyond human intentionality and intervention. This challenges anthropology to consider futures at planetary and geological scales that far exceed traditional human-centred temporal frameworks. Similarly, Vandenberghe (2025) noted that the Anthropocene transforms human self-conception, making humans aware of their finitude and ecological embeddedness.

Considering education as critical infrastructure and individual schools as critical entities is an organisational transition triggered not by the broader social, political, or economic environment nor by intra-organisational changes, but by the anthropological shift marking the transition to the Anthropocene. This organisational transition requires schools to prepare their stakeholders to revise their relationships with themselves, society, and nature to address emerging threats and the ecological crisis effectively.

Conclusion

In conclusion, this paper argues that the transition to the Anthropocene represents a profound anthropological shift, requiring new frameworks for understanding human agency, responsibility, and interconnectedness on a planetary scale. Drawing on the fact that existing models of individual, organisational, and societal transitions do not fully address the complexities and unprecedented challenges of this anthropological transition, the paper highlights the need to broaden the conceptualisation of critical infrastructure beyond traditional sectors to include education. In this context, schools, as critical entities, play a vital role in fostering community awareness of new scales and threats, and in cultivating an ethics of care that embraces social and environmental justice while acknowledging the colonial histories embedded in the Anthropocene narrative. Ultimately, this paper contends that the Anthropocene compels a reimagining of the roles of both education and anthropology in fostering new forms of care, responsibility, accountability, plural worldviews, and an ethics of care for both human and more-than-human futures.

Suggestions for future research

Suggestions for further research should focus on the practical implementation of this conceptual argument to inform transitions theory and provide a deeper understanding of the vital role of education in the Anthropocene.

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