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Contents

HSSE Online is a peer-reviewed electronic journal published by the Humanities and Social Studies Education (HSSE) Department, National Institute of Education, Singapore. The main purpose of the journal is to energize, inform and improve teaching practice in humanities and social studies education and to provide a venue to share ideas, research and resources that will be useful to humanities and social studies teachers and scholars. We invite you to make use of these ideas and resources as well as contribute your own

Editorial: Contemporary Issues in Geography Education: Philosophy, Pedagogy and Practice

This issue of HSSE Online is anchored by the theme "Contemporary Issues in Geography Education: Philosophy, Pedagogy and Practice." The collection brings together a set of articles that collectively examine how Geography education in Singapore is being shaped—and reshaped—by ongoing developments in disciplinary thinking, classroom practice, and broader socio-technological change. While the contributions differ in focus, they are united by a shared concern: how educators interpret, translate, and enact geographical knowledge in ways that remain meaningful and responsive to contemporary educational demands.

Several articles foreground the importance of interrogating the epistemological foundations of Geography as a discipline. Ryan Teo's article highlights how teachers' underlying assumptions about geographical knowledge influence the ways sustainability is framed and taught in the classroom . By drawing attention to the interplay between positivistic, humanistic, and critical traditions, the article reminds us that Geography education is not philosophically neutral, but shaped by competing ways of knowing. This concern is further extended in Clement Tan's discussion of the tensions within the curriculum, where differing geographical traditions may lead to fragmented representations of sustainability. Together, these contributions underscore the need for educators to develop greater philosophical clarity and intentionality in their practice, particularly when engaging with complex and evolving concepts.

The issue also highlights how curricular intentions are mediated through teaching and learning processes. Ng Wen Xin's exploration of the intended, enacted, and experienced curriculum provides a valuable lens for understanding how policy aspirations are translated into classroom realities. The article foregrounds the role of teachers as key mediators of curriculum, whose decisions and interpretations shape students' learning experiences in significant ways. Complementing this perspective, Cheak Su Peng's study on the use of thinking anchors offers a concrete example of pedagogical innovation. By demonstrating how structured scaffolds can enhance students' responses to data response questions, the article illustrates how deliberate instructional design can strengthen disciplinary thinking and improve learning outcomes.

At the level of practice, this issue also engages with emerging challenges and opportunities facing Geography educators. Chua Yan Yu's article on the use of artificial intelligence in Geography classrooms presents a timely examination of how new technologies are influencing teaching and learning. While AI offers clear benefits in terms of efficiency and access to information, the study raises important questions about its limitations in fostering empathy, ethical reasoning, and deeper engagement with sustainability-related issues. This contribution invites educators to critically reflect on how technological tools are integrated into practice, and to consider how they can be used in ways that support, rather than dilute, the broader aims of Geography education.

Taken together, the articles in this issue reflect the dynamic and evolving nature of Geography education. They highlight a field that is simultaneously engaging with foundational philosophical questions, refining pedagogical approaches, and responding to new and emerging challenges in practice. More importantly, they reaffirm the central role of educators as

reflective practitioners who navigate these intersections—making informed decisions about what to teach, how to teach, and why it matters.

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Teaching Sustainability through Geography: Why Teachers' Underlying Assumptions about the Subject Matter

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Abstract

Geography education in Singapore has evolved alongside national priorities, shifting toward a concept-based curriculum centred on sustainable development. This paper argues that the effectiveness of sustainability education partly depends on teachers' underlying philosophical assumptions about geographical knowledge. The current syllabus reflects an interplay of positivistic, humanistic and critical traditions, requiring educators to navigate multiple epistemologies in their teaching. In addition, it is centered around sustainable development as a core anchor for geographical knowledge. As sustainability demands understanding long-term socio-environmental consequences, teachers must intentionally align philosophy, pedagogy and assessment to model conceptual, reflective and critical thinking. Ultimately, geography's capacity to cultivate sustainability-minded students rests on philosophically aware educators who exercise discernment in classroom practice.

Introduction

Geographical education in Singapore has transformed over the decades, in response to the changing geopolitical landscape and national needs (Chang, 2012). Chang observed changes across time from a focus on regional geography, with content largely centred on locational and descriptive information in the 1950s, to an increased interest in conceptually based geography which sought to provide a framework for geographical knowledge to be categorized, meaningfully understood and applied by students by the 1980s. Since then, there have since been regular revisions to the way that these conceptual frameworks are structured and taught, with new pedagogies such as the inquiry-based learning approach coalescing with the geographical investigation (GI) assessment format in recent years (Ministry of Education, 2021; Ministry of Education, 2022). Underpinning geography education, however, are foundational philosophical understandings of geographical knowledge that is embedded in the syllabus and in educators' own minds. This is crucial, since pedagogical content knowledge (PCK) is an inextricable element of each educator's teaching practice (Segall, 2004), and the internalised geographical ontology and epistemology of an educator influences the development of their PCK. As a result, it is imperative that we consider how individual and nation-wide philosophical understandings of geography have shaped the subject's educational landscape and presently impact the way that educators teach

geography.

Philosophical Underpinnings in the Geography Syllabuses

To begin, we will consider how the shift from regional, descriptive geography to concept-based geography has rewired the overall motivations, purpose and outcomes of teaching and learning geography in the Singapore classrooms. Regional geography aimed to create a categorization of natural and human landscapes and activities through geographical demarcations, understanding these phenomena through some form of spatial collectivization. This was then operationalised as a means of proliferating national identities, allowing people who lived within the same region to have a basis for uniting and collaborating with each other, co-existing peacefully and productively (Paasi, 2009). However, while this approach towards geographical education has had its uses and benefits, it quickly became insufficient for Singapore's educational needs. As a nation which seeks to be globally connected and internationally competitive, a switch away from regionalization towards globalization was imperative (Chang & Kidman, 2024). Furthermore, a regional approach limited the application of geography to a purely descriptive discipline instead of presenting it as the high-utility, nigh-ubiquitous, inter-disciplinary subject that it had the potential to be. With these considerations (amidst others) in mind, the epistemological shift of the geography syllabus made a great deal of sense.

In the last 50 years, multiple revisions have been made, and the most recent geography syllabus across all levels comprise of topics that examine both the physical and human aspects of geography (Chang, 2012). This inclusion of both physical and human geographies within topics also illustrate an important ontological underpinning of geography education in Singapore – that we do not merely seek to understand space as an objective reality that is separate from human influence, but rather ought to explore how human societies and the physical environment interact with and within each other to generate the spaces and places that we call home. This ideological shift was captured succinctly in the 1990s' thematic distinctions of "Earth as home for people" and "Earth's natural resources and how humans can improve or damage the environment" (Chang, 2012). These two themes, while no longer officially existing in the current geography syllabus documents, have been enshrined in the concept of sustainable development which has now also been integrated in virtually every topic (Ministry of Education, 2021; Ministry of Education, 2022).

What is the philosophical nature of Singapore's geography syllabus? Is it positivistic, humanistic, critically oriented, or a hybridization of these philosophies and more? First, consider the place for positivism in the geography syllabus. With explanation and prediction of phenomena as a basic outcome of positivism, it encourages learners to adopt the scientific method (often transposed as the geographical method of inquiry) to design and conduct investigations not only about static or material physical phenomena and landforms, but also hypotheses about human interactions and societal phenomena. The positivist ontology, applied in geography, provides a useful impetus for using quantitative methodologies. As Harvey (1969) points out – it develops logical rigour and assists in the composition of convincing and applicable narratives that can be appreciated by geography academics and lay people alike. To use positivism and not be bound by its ontological exclusivism - that is, to limit valid knowledge propositions to that of purely controlled, scientific, model-based, theory-driven

claims – is one of the geography syllabus' advantages.

Second, consider the integrative approach of humanistic and phenomenological ideologies in the modern syllabus. With the inclusion of topics such as *Housing* in lower secondary (Ministry of Education, 2022), *Everyday Geographies* and *Tourism* in upper secondary (Ministry of Education, 2021), and *Development, Economy and Environment* in the pre-university syllabi (Ministry of Education, 2023), the concepts of sense of place and belonging, individual motivations for travel and consumption and other human-facing concepts are central and heavily relied upon. Humanistic geography not only broadens the scope for what can be analysed and examined under the umbrella of geography, it also lends itself to qualitative methodologies, which can be paired with quantitative approaches from positivism. This blend of both methodologies are a feature of the synergistic combination of positivism and humanistic-phenomenological epistemologies that allows the current geography syllabus to leverage on the best of both, without being confined to the ontological exclusion of either.

Third, the critical perspective of geographical knowledge which calls for a tacit distrust in observable phenomena, recognising them as part of a superstructure that is largely influenced by the unseen economic base (Harvey, 1973), or a scepticism of basic knowledge claims on the basis of their socially constructed nature which may or may not be grounded in physical reality. This ontological and epistemological perspective is not explicitly incorporated into the geography syllabus but can yet be infused into the teaching and learning of the subject at the discretion and with the wisdom of individual educators. For example, when leading a discussion on climate change and the role of human activities in the phenomena, educators must be experts about the scientific reasons for climate change and its constituent processes like global warming, the social drivers that cause it, and the economic, social and environmental impacts of the phenomena and the possible solutions to the problem. These can be communicated through a "causality-consequence-management framework" as espoused by (Chang, 2013). However, none of this truly addresses the fact that beneath the surface, it is in fact the capitalistic, consumption-driven, economic development-motivated global system that is resulting in a global resource exhaustion and unsustainable expansion of manufacturing and agriculture into natural forests and oceans, that is morally and physically destroying our Earth. The moral implications of the content and concepts that are covered in geography can only be broached by moral and empathetic, sensitive and wise educators who employ their own critical understanding of the world around them, coupled with the prescribed syllabus (Chang, 2013). This is, in essence, the most important way in which geographic philosophical traditions come together and play an understated but crucial role in geography education in Singapore.

Geography Teachers and Sustainability Education

Moving on, we will consider the reasons why concept-based geography, taught through the lens of a tri-layered philosophy, is well-positioned to educate Singaporean students about sustainable development – perhaps more so than any other subject. Meadows (2020) asserts that the nature of geography as explicitly spatial, possessing a scope that holistically encompasses every aspect of the physical and human environment and their interactions and resultant impacts with and on each other, allows the subject to grasp the broad scope

and spectrum of variables that pertain to sustainable development. To take it a step further, geography has also acquired the necessary terminologies to effectively communicate these elements of sustainable development to students of all ages, making it suitable as a launch pad into public and political discourse (Meadows, 2020).

For an educator the ability to draw from a well-defined nomenclature, with a range of epistemological traditions and complementing methodologies to frame and derive knowledge claims is a significant advantage. It therefore boils down to the teacher's own personal consolidation and technical expertise in wielding the philosophies, pedagogies and terminologies appropriately in their design of lessons and assessments that will determine how well students eventually grasp the concept and relevance of sustainable development. This is precisely why educators' professional development is incorporated in every school and there are calls for associations of educators to constantly gather to refresh and sharpen their perspectives, pedagogical practices and philosophical approaches to meet the needs of geography education (Chang, 2013).

Consider some specific examples in the current syllabus. Sustainable development is positioned as the third theme of each human geography topic in the upper secondary school syllabus (Ministry of Education, 2021). If we take a closer look, there are also clear nods toward sustainable practices even in the physical geography clusters of *Climate* and *Tectonics*, where students are trained to think about how humans affect and are impacted by environmental factors, and the ways we can adapt to develop sustainably. It can be effectively concluded that the outcome of the current Singapore geography syllabus is to lay the foundations, build the appropriate scaffolds, and guide students to think about how all aspects of life need to be lived and experienced with sustainability at the core. How then can an educator exercise his/her own wisdom and discretion, using the various philosophical paradigms to guide students such that the latter begin to grow in their own geographical wisdom and discretion?

One approach to achieve this is for educators to adopt the Understanding by Design (UbD) approach espoused by Wiggins & McTighe (2005), first considering the learning outcomes, working backwards to consider what would be acceptable evidence to demonstrate those outcomes, and finally planning the most appropriate activities to collect and organise such evidence. This approach spells out the pedagogical development flow that the educator takes but also requires them to be entirely cognizant and intentional about the application of their ontology, epistemology and methodology in constructing geographical knowledge. For instance, when teaching about sustainable tourism development, the educator must consider what big ideas and skills they want to impart to their students. Is there an objectively true or right way to attain a sustainable future for the tourism industry that can be discovered quantitatively? Or is there a need for reflexivity to observe the patterns of anthropogenic activities and propose improvements to the current sustainable approaches to tourism like eco-tourism and community-based tourism? How important, really, is the human experience and individuals' personal understanding of sustainability and tourism in analysing these sustainable tourism approaches? This is determined by the educator's positioning along the positivism-humanism-critical ontology spectrum.

Moving further, in developing the assessment tasks which are not purely for grading students, but which allow students

to flesh out and demonstrate their own reasoning and consolidate their learning of the content and skills, the educator must be crystal clear in the epistemological approach toward the geographical knowledge they desire to communicate. For instance, if the educator wants the student to perceive their geographical education as more than a smattering of content knowledge and haphazard concepts, but rather a moral and ethically-grounded composition of meaningful concepts grounded in real-world scenarios that has relevance to their lives (Chang & Seow, 2018), then there must be a deliberate inclusion of continual and formative assessments which require students to do more than regurgitate spatially distant examples. Assessments must require students to think for themselves, to use both qualitative and quantitative methods of data collection to craft compelling narratives and even question and critically evaluate pre-existing notions of right and wrong, advised and disadvised, to truly progress students toward independent geographical mastery. This must be first modelled by the teacher in class through teacher talk, discussion-based learning, and formal as well as informal inquiry throughout the course of the year. This means that the teacher's epistemology must be wholly congruent with that which they hope their students eventually adopt. The methodologies for this are endless, from GI, technology-assisted learning with programmes like StoryMaps and other geographical information systems (GIS) like Google Earth Pro and Qgis, as well as collaborative learning platforms like Padlet and Google Classroom which allow students to share and build upon each other's ideas both synchronously and asynchronously. The educator's responsibility is to be fluent in these available technologies and their affordances to expand their own students' learning experiences.

While there are undoubtedly many more instances in which an educator's philosophy and pedagogy coalesce to define their teaching practices, I have endeavoured to highlight the main reasons why the educator's underlying assumptions about the nature, construction and application of geographical knowledge impact their approach towards teaching it. Sustainable development is a core concept in the geography syllabus for good cause, being one of the most pressing and prominent discourses of the modern era. Geography, in its (minimally) tri-layered philosophical grounding and broad scope of topics and concepts, is well-positioned to develop students into thinkers and innovators of Singapore's future sustainable development, but this is dependent on educators' constant professional development and willingness to exercise their wisdom, discernment and reflexivity in applying the appropriate philosophical grounding of geography in the classroom.

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A Fragmented Sustainability Education? Reconciling Geographical Philosophies for Student Learning and Practice

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Abstract

Geography occupies a distinctive position in educational curriculum, often being tasked with the role of educating and advancing student knowledge in sustainability. However, contrasting geographical traditions, particularly positivism and humanism, has shaped the framing of sustainability in Singapore's secondary school geography syllabuses. A close examination of the syllabuses reveals that although sustainability exists as an overarching thematic anchor across the topics, its articulation varies according to topical demands. However, if the curriculum sets out a fragmented landscape of learning about sustainability, its ability to move student behaviours towards sustainable praxis may be limited. This essay argues that there is room for a thorough interrogation of sustainability as a concept within the Singapore secondary school geography curriculum that goes beyond how it is presented in the syllabuses. Furthermore, a more meaningful engagement with the dynamic and highly principled nature of the concept could translate into more thoughtful and practising learners.

Introduction

Geography is a peculiar subject of study to be sure. It attempts to present a single, unified and interconnected facade, yet is built upon a variety of philosophical traditions, some of which are fundamentally in conflict. In spite of this, many (Windsor & Kriewaldt, 2023; Miao et al., 2022) are still in agreement that geography is uniquely positioned to accomplish an important task – educating about sustainability issues. Its ability to combine insights from both the natural and social sciences enables learners of the subject to attain a clearer picture of the human-environment relationships (Casinader & Kidman, 2018) which are integral to sustainability education.

The Theory of Practice Architectures examines how the varied arrangement of a site can influence an individual's decision to enact practice (Kemmis, 2023). When extended to the landscape of geographical education, Windsor & Kriewaldt (2023) stress the importance of attending to the arrangements in any site of learning and to be cognisant of how they can steer the decisions of learners towards or away from praxis. In essence, the framing of the curriculum sets out the landscape of learning for students. An important aspect

of this arrangement is the school curriculum. Previous studies (Winter, 1996) have discussed how epistemic influences, especially the dominance of certain strands of thought, can easily shape what students learn in school geography. Therefore, using a close consideration of the ways in which the geography syllabuses are presented, this essay will explore the degree to which different geographical traditions are presented to students in Singapore and how this affects their learning about the pathways to achieving a sustainable future.

Contrasting geographical traditions & Singapore's geography education

School geography curricula have always been mindful of the development of academic geography. This is especially problematic because geographers themselves, "do not agree on what things can be said to exist; what things matter and why; and how knowledge of these things can be produced" (Huckle, 2020, p. 139). Essentially, geographers tend to diverge in their ontology, epistemology, and methodology. Changes in school curricula to counter the dominance of certain strands in geographical thinking, such as the introduction of everyday knowledges to balance a highly positivistic and empirical geography, have also been implemented to improve the student experience through "accurately [reflecting] how students learn and to be more relevant to their present and future lives" (p. 143). In Singapore, school geography arguably follows closely behind the development of academic geography. The secondary school geography curriculum (Ministry of Education, 2021) presents sustainability issues using geographical knowledge built upon various philosophical traditions, mainly positivism and humanism - with varying levels of prominence in the various topics of study.

Positivism is a geographical tradition characterised by a need to make sense of the world through the observable and measurable, where knowledge is based upon verifiable evidence. Schaefer (1953), a prominent figure in positivistic geography, argued that geography should seek out spatial differences between places, present laws on spatial phenomena, and create generalisable knowledge through rigorous study and the use of instruments. Huckle (2020) noted that such a view of geographical knowledge had a stranglehold on the state of the subject in schools at the start of the 21st century. He also argued that a geographical education rooted in positivism was able to market itself as "scientific and objective" (p. 139), therefore contributing to its popularity. Singapore's geography syllabus still values such positivistic knowledge, enshrining the acquisition of content in the form of "factual, conceptual, and procedural knowledge" (Ministry of Education, 2021, p. 21).

However, in the face of the abundance of factual knowledge under this paradigm, Lambert & Morgan (2010) pointed out that such geography teaching produced students who were unable to engage with important issues of social change. Instead, they proposed that students be taught instead about how to appropriate geographical concepts to make sense of the world on their own rather than relying solely on scientific knowledge. This, alongside the debate on powerful knowledge at the time may have caused Singapore school geography to shift. Today, teaching geographical concepts and geographical inquiry as "[ways] of thinking about the world" and "[ways] of knowing the world" respectively (Ministry of Education, 2021, p. 11) is a key goal. This was a bid to enable students to acquire specialised and powerful knowledge that would enable them to take their understandings beyond their specific context of learning in schools and apply

them to real life (Young, 2010).

Further development of Singapore's school geography followed calls to emphasise students' everyday experiences. Roberts (2013) argued that everyday knowledge has extensive potential within a syllabus since it allows students to connect what they have experienced and knowledge they have gained in life to larger concepts they learn in schools. This makes it a highly relevant and powerful form of knowledge. The Singapore geography syllabus is strongly aligned with Roberts' view, with its inclusion of an entire cluster titled *Geography in Everyday Life* in its upper secondary syllabus. This cluster is even meant to lay the foundations for understanding key concepts in other clusters such as *Tourism*, *Tectonics*, and *Climate* through an "integrated" approach (Ministry of Education, 2023, p. 22). It features common everyday experiences of Singaporean students, including the context of urban neighbourhoods, to introduce concepts of urban planning and especially, sustainability. This focus on the lived experiences is bred from the geographical tradition of humanism. Tuan (1990) shifted the attention of geographers towards more personal affections and attachments to spaces, highlighting the agency of individuals in perceiving a place with their senses, forming meaningful bonds, attitudes, and understandings of place. Therefore, it is apparent that geography education in Singapore is influenced by a mix of geographical traditions and conceptualisations of geographical knowledge, alongside what is deemed important for students to know. What remains to be said is how these contrasting traditions shape the way sustainability is framed and, subsequently, received by the student.

A possibly fragmented sustainability?

In its geography syllabus, Singapore enshrines sustainability as a key principle in both lower and upper secondary study. Sustainability is used as an overarching theme at lower secondary levels, where the syllabus is completely framed around the concept of sustainable resource use and management (Ministry of Education, 2021). The thematic focus is aimed at giving students "insights" into sustainability issues, while also prompting "[contemplation of] the possible responses which people can take to resolve these issues" (p. 6). This is consistent with the upper secondary syllabus' explicit aim of enabling students to "be imbibed with a sense of responsibility towards the environment" and to possess "a desire to contribute towards building a sustainable future" (Ministry of Education, 2023, p. 9). Using sustainability as an anchor concept allows for repeated engagement and provides "opportunities to revisit ideas, knowledge and skills in different contexts to reinforce the learning" (Ministry of Education, 2023, p. 18). Evidently, there is a hope that geography education would enable students not only to comprehend sustainability issues, but to be galvanised to practice sustainable actions

However, as described earlier, the syllabus itself is constructed from a mix of geographical traditions, which could affect the kind of sustainability being presented to students. Lambert & Morgan (2010) mention how "the world of geography can appear very fragmented" (p. 163), especially without a good philosophical understanding of geography as a discipline. Singapore's geography syllabus organises content to facilitate an inquiry-based learning approach and therefore fits the learning about concepts under sets of guiding questions. These questions are then organised within topics designed to progress from learning about aspects of geographical phenomenon, to their features

and location, and eventually, how they affect the relationship between environment and people and how they can be made sustainable (Ministry of Education, 2021). While this ensures that sustainability is explored within every topic, there is thus an inherent risk of causing the teaching of sustainability to be highly isolated within each topic.

Even when comparing across different topics, there exist some differences in what kind of sustainability is being taught to students. For instance, at upper secondary levels, sustainability morphs to accommodate the demands of the topic being taught and to ensure relevance, such as sustainability appearing as "disaster risk management" and "climate action" in the study of tectonics and climate respectively. Although these are undoubtably aspects of sustainability, there is a notable shift towards management of environmental rather than social aspects of sustainability. This difference is not explicitly addressed within each topic in the syllabus. Adding to this complexity, Kagawa (2007) warns that a teaching of fragmented bits of sustainability without explicitly addressing the interconnectedness of these different aspects produces students who display "dissonances" in terms of their perceptions of sustainability and their actual behavioural choices (p. 333).

A range of actions are taught to students in sustainable development, from technocratic and managerial decision-making which draws upon theories and conceptual understandings gleaned scientifically, to the everyday neighbourhood community decisions to promote volunteerism and environmental stewardship. Students therefore are expected to rationalise their scale of impact and the feasibility of their actions considering all the possibilities presented to them. As Kagawa (2007) found, this could lead to student perceptions of sustainability that are rather paralyzing rather than enabling, where they may agree with radical statements about environmental action such as the need to transform entire lifestyles to suit sustainability, while still dabbling only in mild actions concerned with personal consumption. This incongruency between the perceptions of sustainability the geography syllabus breeds and the perceived scale of action accessible to students could affect their conception of the possible pathways to a sustainable future.

Reconciling "sustainability"

Borrowing from Young's (2014) conception of powerful knowledge, "knowledge is 'powerful' if it predicts, if it explains, if it enables you to envisage alternatives" (p. 74). As the framing currently stands, the theme of sustainability itself is not brought into question - its definition and pathways to its achievement are presented as unmalleable. At the same time, while the syllabus does present social-economic dimensions to sustainability at times, there is a continuous theming around the need to manage human-environment relationships. However, there is another tradition within geography – a critical and analytical school of thought studies the hegemonic structural forces that undergird economic and social systems, and which impact on humanity's view of the environment and of nature. For older students, perhaps, it might be useful to expand discussions of sustainability in this direction.

The goal of a geography curriculum would therefore be to liberate rather than paralyze students in terms of enacting sustainable practice in their daily lives. Concrete means of doing this can include inviting students to examine how different groups examine and define sustainability,

including asking them to ponder why sustainability is articulated differently in each topic. Perhaps, students should be guided towards discussing sustainability as an undergirding principle for analysing strategies and trends rather than an unwieldy concept that has a strict definition. Teachers can prompt students to use their understandings of sustainability as a tool that helps them to rationalise human actions and their impacts on the environments to spotlight its relevance in their daily lives.

Conclusion

In conclusion, curriculum makers and enactors have to be cognisant of how sustainability is presented to students. Because contrasting dominant geographical traditions drive academic geography, and therefore school geography, learners may be presented with a possibly fragmented and malleable form of sustainability. If this seemingly amorphous form of sustainability is projected onto students without much room for criticality and discussion, there is a danger in limiting the degree of sustainability of their actions in the future. Therefore, mindfulness has to be paid to the "architecture" of a sustainability curriculum, that is the ways in which ideas are organised, connected, and made open to examination.

Admittedly, the curriculum is but one aspect of a learning experience that can influence how learners learn about and are empowered to think and act sustainably. As Kremmis (2023) plainly states, "practices are secured interactionally, in characteristic sayings, doings and relatings, and by the cultural-discursive, material-economic and social-political arrangements that hold them in their course" (p. 19). Evidently, this essay's discussion on the curriculum does not paint a full picture of how sustainability is characterised and presented to learners. Discourse and language used by teachers, who enact the curriculum, would be another area of interrogation that could greatly influence the notions of sustainability eventually gleaned by the learner. Thus, the goal is not to present sustainability as a static, thematic trend. Instead, we should be thinking about how to cultivate the conditions under which it can be explored as a dynamic principle that empowers learners to thoughtfully consider the types of futures they want to see and work towards.

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The Intended, Enacted and Experienced Curriculum: Realising Sustainability Education through Singapore Secondary Geography

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Abstract

This paper examines the strengths and constraints of the Singapore Secondary Geography curriculum in advancing sustainability education and suggests that current approaches to sustainability can lead to simplified representations of climate solutions, limited engagement with social and ethical trade-offs, and insufficient attention to unequal impacts across places and communities, even within student-centred classroom contexts.Drawing on lesson examples, learning artefacts and student reflections, this paper illustrates how teacher curriculum-making enables the enacted curriculum to complement the intended curriculum in equipping students to think through systems, recognise contested sustainability pathways, and act as informed stewards of their environment. Through intentional task design, scaffolded inquiry and reflective dialogue, classroom enactment moves learning beyond discrete topics towards understanding the consequences and feedback loops across human and environmental systems. Sustainability is therefore approached not as arriving at a set of correct answers, but as exercising judgment through ethical reasoning and careful considerations of trade-offs.

Introduction

Sustainability education is increasingly emphasised as a key driver for sustainable development (Becker, 2018; Boström et al., 2018). Moving beyond traditional environmental education, which focuses on raising awareness of ecological challenges, sustainability education inculcates in learners the knowledge, skills, attitudes and values required to take individual and collective action in addressing present and future environmental, economic and social challenges. (Elegbede et al., 2023) Geography is particularly well placed to advance sustainability education. As an integrating discipline that spans the sciences, social sciences and humanities, it encourages learners to think critically about the nuances and complexities of human-nature interactions, to recognise the inequalities that impact the wellbeing of people and the planet, and to reflect on their agency in shaping a sustainable future. The Singapore Secondary Geography syllabus foregrounds themes of sustainable development, introducing topics on sustainable resource use and management

in the Lower Secondary curriculum, with further exploration of human-environment relationships and sustainability challenges in the Upper Secondary curriculum (Ministry of Education, 2023). This reflects a deliberate progression to deepen learners' use of disciplinary lenses in critically engaging with sustainability. However, the extent to which it promotes sustainability education in terms of building empathy and transforming behaviour needs more careful examination. This paper examines the strengths and limitations of the Singapore Secondary Geography curriculum in supporting sustainability education and proposes possible approaches to strengthening its capacity to nurture not only cognitive understanding, but also the socio-emotional dispositions and behavioural changes that will enable learners to contribute to environmentally sound, economically viable and socially inclusive futures.

Curriculum Enablers and Constraints for Sustainability Education in Geography

Geography as an Integrative Discipline for Sustainability Education

A key strength of the Geography curriculum lies in its intentionality in connecting natural and human systems across the topics explored. This allows learners to recognise the interdependence between humans and the physical environment, in that humans extract resources from the physical environment, while physical environments are sustained and increasingly shaped by anthropogenic activities. This framing is crucial for sustainability education, which requires learners to grasp the ecological, economic and social implications of human-nature interactions. The *Geography in Everyday Life* Cluster (Upper Secondary Geography)(Ministry of Education, 2023) illustrates this interconnectedness clearly. Learners explore the ecosystem services nature provides for humans, while examining how some human actions– through urbanisation, pollution and resource extraction–can degrade the physical environment. This enables learners to make connections between theory and their lived experiences. For a highly-urbanised and resource-scarce country like Singapore, the inclusion of this topic helps make sustainability issues locally relevant.

While the interdisciplinary nature of Geography provides a strong foundation for sustainability education, the way interconnectedness is represented shapes the type of sustainability consciousness that learners develop. In practice, this interconnectedness often carries a utilitarian slant, framing the environment primarily in terms of the resources and services it provides for human use, rather than as a system with intrinsic value and hence something worth safeguarding. This appears to align with pragmatic state narratives, where resource efficiency and the survival of our small island state is often espoused, with responses to environmental issues often framed in terms of initiatives that generate material value or advance the country's economic competitiveness (Han, 2017). In the case of climate action, this translates into investing in low carbon technologies, exploring alternative energy imports or redesigning infrastructure to adapt to sea-level rise. Mentions of the role of individual action in the curriculum, such as making more sustainable consumption choices, are comparatively scant. While it is true that individual action is limited in addressing systemic challenges that require significant infrastructural and geopolitical transformation, neglecting the dimensions of ethical responsibility and empathy may mean confining the curriculum's capacity to nurture a deeper ecological consciousness, one that encourages learners

to see themselves as embedded within, rather than separate from, the natural world. (Heikkinen et al., 2024). Without this deeper mindset shift, sustainability education risks producing technically competent learners who may be able to calculate the costs and benefits of human actions but with limited sense of responsibility or stewardship. Consideration may therefore extend unevenly, leaving both non-human life and communities who bear the disproportionate burdens of sustainability transitions at the margins.

Representations of Sustainability Challenges

The Secondary Geography syllabus also introduces learners to contemporary issues such as sustainable urban planning, water management and renewable energy, ensuring that learners are exposed to globally relevant debates (Ministry of Education, 2021, pp. 16–17). This provides opportunities for learners to unpack and apply disciplinary concepts in addressing current and future-oriented challenges. However, when it comes to prompting learners to reflect more deeply on the impacts of human action or inaction, the way these topics are represented often stops short of cultivating the type of critical thinking that sustainability education demands of learners. The treatment of climate mitigation strategies provides a case in point.

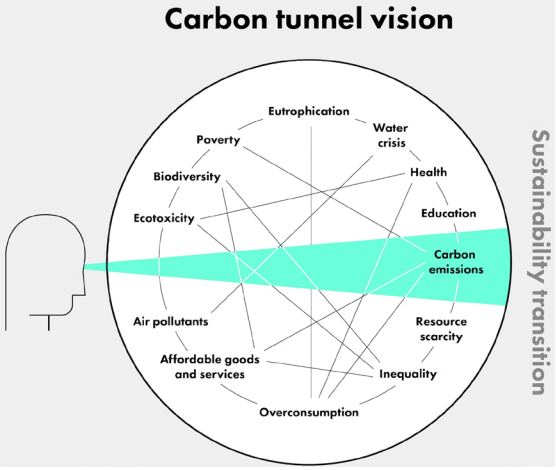
While learners are prompted to consider the benefits and limitations of various low-carbon technologies and clean energy sources, the ideas tend to be presented in an overly-simplistic and decontextualised manner. Solar, hydroelectric, geothermal and nuclear energy are broadly examined in terms of their technical feasibility and energy efficiency, without significant exploration of the wider systemic impacts on the natural systems. For instance, while solar energy is often hailed as a clean alternative to fossil fuels, there is no mention of the environmental costs associated with the mining of rare transition minerals to produce photovoltaic cells (Global Witness, 2024) or the waste management challenges societies will face at the end of the photovoltaic panels' life cycle (Xia, Yang & Poon, 2025). In the context of hydropower, the harms associated with dam construction are also not explored, including the trapping of nutrient-rich sediments upstream which reduces downstream productivity and contributes to declining fish catches (Chen, Shi & Huisman et al., 2020). This issue is particularly salient in the Mekong River basin, where the river's transboundary nature means that extensive coordination among multiple countries is required to ensure that renewable energy deployment does not undermine long-term economic and environmental sustainability. This is compounded by the power asymmetry in the region, with China's upstream position and greater infrastructural and political influence giving the country more leverage over downstream outcomes.

Little attention is also given to the social repercussions of sustainability decisions, particularly the unequal distribution of benefits and burdens across different spaces and scales. While the transition to a low-carbon future brings global benefits, it poses significant risks for workers in fossil-fuel-dependent economies. The International Energy Agency (IEA) reported that the coal supply industry saw approximately 225,000 job losses between 2019 and 2022, with coal miners bearing the brunt of the transition (IEA, 2023). An additional 1.4 million jobs, primarily in Asian countries such as China and India, also remain vulnerable to displacement by 2030. In the same vein, the land-use impacts of large-scale energy and

development projects often fall disproportionately on rural communities, while urban populations benefit from clean energy and economic gains. Within Southeast Asia, the ongoing development of Rempang Eco-City, a China-backed project to turn the Indonesian island into a solar manufacturing hub, threatens to displace 7,500 Indigenous inhabitants, many of whom belong to the Orang Darat tribe. Beyond the violent confrontations and surprise demolitions of their homes faced by the community as part of the project's land-clearing efforts (Eco-Business, 2024), these developments would result in the loss of cultural identity and source of livelihoods for the predominantly Malay fishing communities with deep ancestral ties to the land. (Channel News Asia, 2023). A just transition therefore cannot be achieved through changes in technology alone. It involves meaningful consultation with affected communities, retraining and reskilling opportunities that enable participation in emerging renewable-energy sectors, and, where livelihoods and cultural ties are irreversibly disrupted, appropriate compensation or reparative measures.

The narrow framing of the effectiveness of sustainable development strategies may mean that learners are not exposed to the hidden trade-offs and unintended consequences that climate solutions bring. As such, we risk reinforcing a *carbon tunnel vision*, where solutions are evaluated solely based on their ability to reduce carbon emissions while ignoring all other environmental and social dimensions (Konietzko, 2021)(Fig 1). By focusing predominantly on the technologies in isolation, we risk presenting only a partial picture - one that glorifies alternative energy without closer inspection of possible resource exploitation, economic dependencies or the geopolitical dynamics surrounding it. To strengthen sustainability education, it is therefore crucial to broaden the curriculum's frame to one that provides students with opportunities to engage with the conflict dimensions of sustainability decisions (Boström et al., 2018).

Fig 1. Carbon Tunnel Vision (Konietzko, 2021)



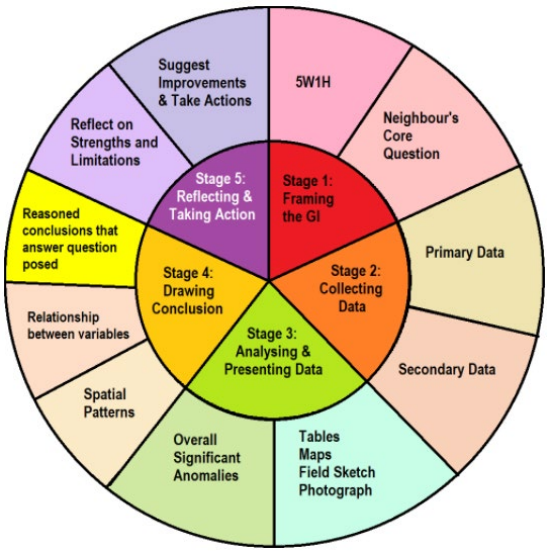
Fieldwork and Geographical Inquiry: Potential and Pitfalls

In both the Lower Secondary and Upper Secondary syllabus, students go through Geographical Investigations (GI), carrying out fieldwork following key stages of the inquiry cycle (Fig 2). They first come up with an inquiry question and decide on appropriate fieldwork methods before going into the field to gather data that will help them address their inquiry. They then analyse the data collected, with the GI culminating in the application of what they have learnt to evaluate their findings and draw conclusions. The inquiry framework provides a structured approach that allows students to engage with sustainability challenges through authentic inquiry. When framing the inquiry, students engage with real issues that affect people and places. When collecting data, they observe first-hand how human and natural systems interact in specific local contexts. When they analyse and interpret what they have gathered, the anomalies they grapple with

will help them recognise that geographical phenomena are shaped by the uniqueness of place. This thus deepens their understanding of the geographical concept of place and helps them appreciate how different communities may experience environmental impacts differently.

Stage 5 of the Lower Secondary GI, which focuses on reflecting and taking action, is especially relevant to sustainability education. Beyond describing and explaining how their findings relate to broader sustainability challenges, it invites students to consider how different stakeholders, including individuals and communities, can respond to these challenges. Through this reflection, students will begin to see themselves as actors with a role to play in shaping a more sustainable future.

Fig 2. Stages of Geographical Investigation (Ministry of Education, 2021)



In theory, the GI process is designed to be student-directed, with learners taking ownership of the entire inquiry cycle and exploring the complexity of sustainability issues through repeated cycles of inquiry. In practice, however, the full potential of fieldwork in supporting sustainability education is not always realised. Teacher dispositions, confidence in facilitating open-ended inquiry and practical constraints such as limited curriculum time, logistical demands and assessment requirements can limit the extent to which GI functions as a genuinely student-led investigation (Chew, 2008). Seow, Chang and Irvine (2019) found that teachers often adopted a teacher-directed approach to inquiry, largely due to concerns about students' readiness for independent investigation. Consequently, they make most of the decisions about the scope, methods and parameters of the fieldwork, down to the selection of the fieldsite, leaving students mainly to follow instructions. Over time, this contributes to mere procedural enactments of GI, where teachers are positioned as providers of knowledge. This ultimately limits the authenticity of the experience and reduces students' sense of ownership over the inquiry process. While the 2023 Upper Secondary syllabus introduced bite-sized fieldwork, designed to be accessible through day-to-day classroom instruction (Ministry of Education, 2023) (Fig 3) to overcome practical challenges of limited curriculum time and logistical demands, this approach also comes with trade-offs. Such activities may be piecemeal in nature - the depth and complexity of inquiry that students can engage in may be limited, further constraining opportunities for student autonomy.

Fig 3. Bite-sized and extended fieldwork (Ministry of Education, 2023)

Bite-sized Fieldwork	Extended Fieldwork
Designed to be accessible through day-to-day classroom instruction.	Designed as an engaging learning experience for students to acquire a deep understanding of geographical phenomena or issues that they are passionate to investigate.
Fieldwork skills can be integrated into the teaching of each topic or cluster.	Geography in Everyday Life Cluster will be applied by students to carry out in-depth study of any content area featured in the neighbourhood contexts and/or the prescribed clusters.
Not necessary for teachers to create a full-length fieldwork experience for students.	Teachers can consider differentiating content, process and product according to their students' interests, readiness and learning profile when designing a school-based fieldwork.

Strengthening Sustainability Education in Geography

Reframing Curriculum Through Systems Thinking

To realise the potential of Geography education in building empathy and transforming behaviour, teachers can interpret the curriculum through the lens of systems thinking—making sense of the complexities of the world by examining the relationships and underlying structures governing it rather than seeing them in silos or a sum of its parts (Meadows, 2008). Curriculum-making can be a powerful lever for change: when introducing students to geographical phenomena, teachers can help them see how issues are situated within a larger context, and how our decisions as individuals, organisations or nations shape not only local but also regional and global outcomes.

This can be done through frameworks or teaching tools that help students look beyond what is on the surface when examining sustainability challenges and trace how impacts link to deeper structural and ideological roots. One such teaching tool is the *Inequalitree*. Created by Ayendri Perera-Riddell, the Inequalitree illustrates the daily impacts, structural enablers and deep-seated ideologies of a social issue. In building an Inequalitree, learners assess sources of information, synthesise diverse perspectives and understand causes and implications of societal issues (University of British Columbia, n.d.). Fig 4 and 5 introduce how the Inequalitree can be used to frame and synthesise insights from case studies related to sustainability issues, while Fig 6 presents the learning artefacts produced by Geography student-teachers in a workshop I conducted, when they were introduced to this teaching tool and used it to unpack the impacts, institutions and underlying narratives behind the damming of the Mekong River, among other regional energy projects.

Fig 4. Inequalitree framework (Credits: EnergyCoLab)

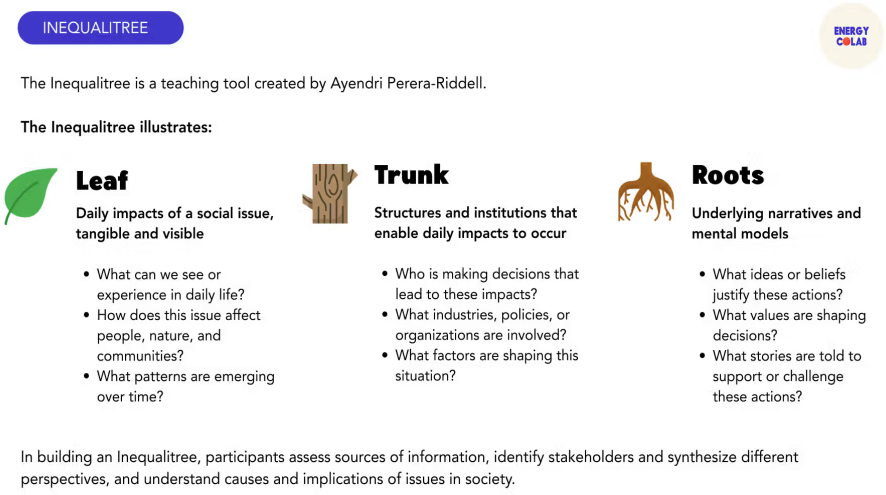


Fig 5. Application of the Inequalitree framework to synthesise insights from case studies (Credits: EnergyCoLab)

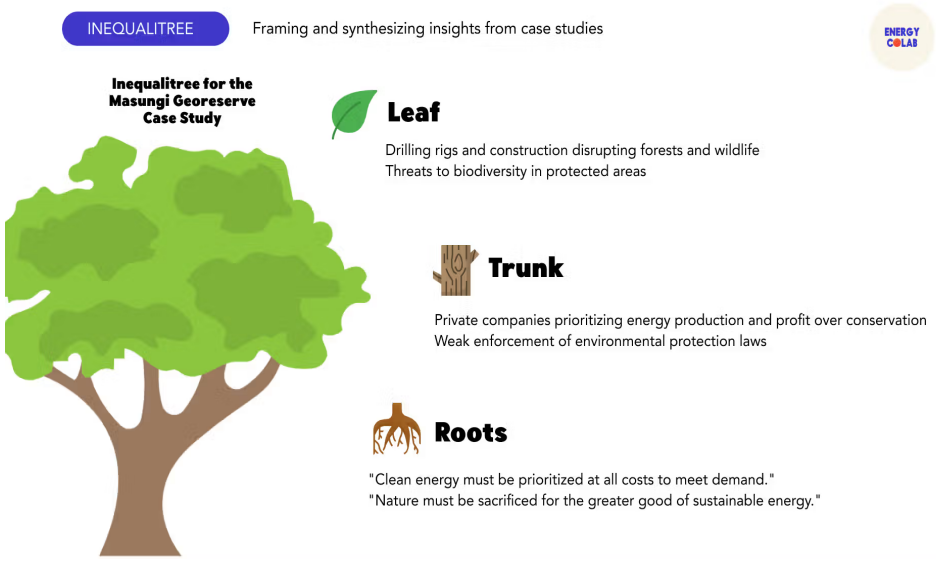
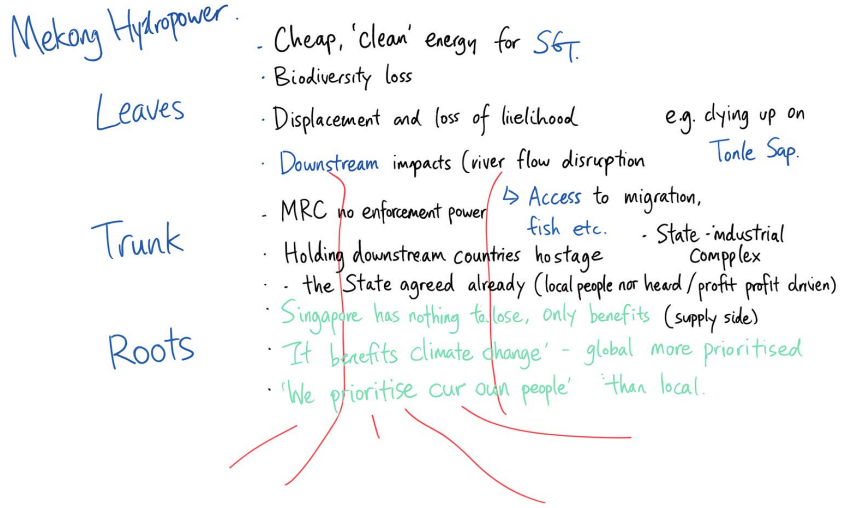


Fig. 6 Student-teachers' Inequalitree on the impacts and underlying drivers of Mekong hydropower development



In the context of sustainability education, learning experiences anchored by systems thinking encourage learners to question who gains and who loses in various sustainability pathways. In other words, it engages learners not only in terms of what solutions exist, but also how these solutions are contested across scales of society. This helps them recognise that the impacts from policy decisions invariably ripple across economic, environmental and social systems; that a corporation or nation's choice does only affect itself alone but also shapes regional and even international outcomes.

In the Inequalitree example above (Fig 6), learners came to the realisation that the way one country finances clean energy projects can shift environmental and social burdens onto neighbouring countries, and how the decision reflects a prioritisation of national interests over the common good while reinforcing existing power relations. This moves them beyond superficial evaluation of renewables from the economic or technical standpoint, prompting them to consider the deep institutional changes required for a sustainable future. This empowers them to ask critical questions and contributes to more informed and responsible decisions in their communities.

Game-based approaches, complemented by guided reflection, can also reinforce systems thinking and invite students to see sustainability issues as a complex and interconnected system, and themselves as a player that can influence outcomes. An example would be the Climate Fresk, a game that teaches players the fundamental science behind climate change and empowers them to take action (Climate Fresk, n.d.). Through collaborative game-based exploration, learners co-construct knowledge, unpack the cause-and-effect relationships behind climate change and reflect on the emotions raised before collaboratively identifying individual and collective solutions. Insights from my facilitation of the Climate Fresk workshop for young learners (aged 9-13) suggest that game-based learning not only connects the science to learners' head knowledge, but also to their emotions and sense of agency when it comes to climate action.

The workshop incorporated a reflective

exercise based on the head, heart and hands model (Orr, 1992). Learners articulated (a) the knowledge they gained (*Head*: What did you learn? What surprised you?), (b) their affective responses (*Heart*: How did it make you feel? What emotions surfaced?) and (c) their commitment (*Hands*: What small actions can you take, starting today?) Their responses demonstrated their appreciation of the interconnections within the climate systems and the reinforcing feedback loops.

> *One thing that I've learned today that I think is important is how one single thing leads to many many consequences. I think this is important because just turning on the aircon often will cause effects like global warming, melting of glaciers, floods and starvation.*

The learners also demonstrated their awareness of the unequal burdens of climate change and expressed their concrete commitments to behavioural change.

> *Homeless people will be the most affected by climate change. They do not have the [resources] to prepare for it, like a house to be safe in and food that are nutritious. This makes me feel sad.*

> *One thing that I will like to change in my life to help the Earth is to recycle more often and not buy things excessively. I will also encourage my family and friends [to do the same].*

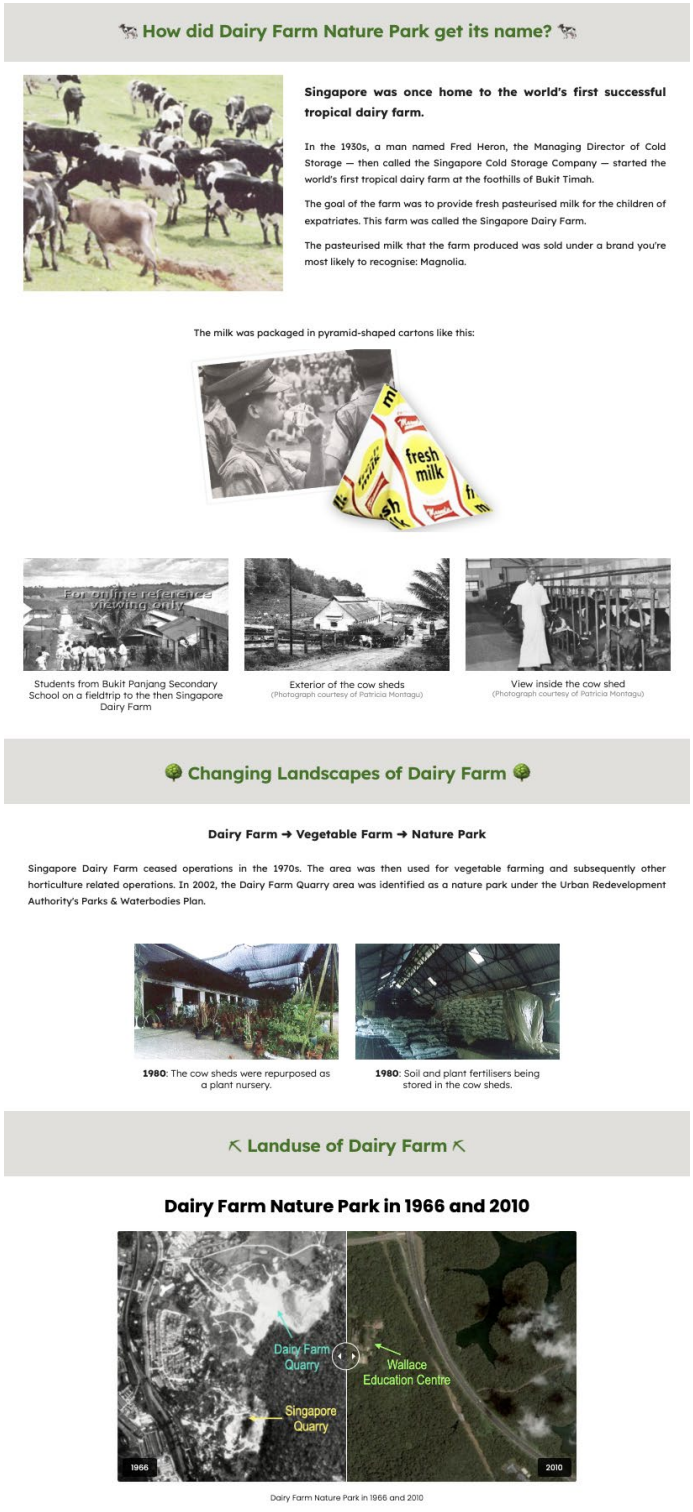
These responses illustrate how game-based learning, together with guided consolidation, can support students in connecting cognitive understanding, emotional engagement and a sense of agency, all of which are key dimensions of transformative sustainability education (Sipos, Battisti & Grimm, 2008).

Building Ownership and Agency Through Student-Directed Field-based Learning

As outlined earlier in the previous section, fieldwork—when designed with students as active inquiry learners in mind—can serve as a powerful vehicle for sustainability education by allowing students to explore sustainability issues within their context, examine human-nature relationships through direct observations and be involved in reflective decision-making. This potential is exemplified in the Secondary 1 GI that I designed and carried out as part of my teaching practice, where students formulated their own hypotheses about the impacts of human modification on the natural environment at Dairy Farm Nature Park, collected primary data, synthesised their findings and reflected on possible responses to sustainability concerns they observed.

Prior to the fieldwork, students were introduced to the history and evolution of the park, from its past function as a dairy farm and quarrying site that caused environmental degradation, to its current land use as a nature park following rehabilitation efforts (Fig 7). In groups, students then formed their own hypothesis to the inquiry question: "How do human activities affect our natural environment?". They predicted that environmental conditions such as temperature and noise levels would vary depending on the degree of human modification.

Fig 7. Teacher-created Google Site designed to situate students within the socio-ecological history of Dairy Farm Nature Park.



During the actual fieldwork, students gathered primary data, including temperature, wind speed and noise levels across multiple checkpoints with differing degrees of human modification. Given that these variables stemmed from students' own hypotheses, the data collection process empowered them as producers instead of consumers of knowledge. The data collected was represented visually with the use of heat maps and graphs, which complemented the observations and photographs students populated in a shared slide deck (Fig 8). Together, these sources of empirical data supported class discussions and enabled students to validate their initial hypotheses. Finally, students evaluated the strengths and limitations of the GI and proposed actions to reduce human impacts at the individual and community levels.

While the overarching inquiry question and the choice of fieldsite were predetermined by the teacher, students were able to exercise meaningful agency throughout the inquiry process. Because they had formulated their own hypothesis, they also determined what forms of data would be needed to test them. As a result, the photographs, field observations and weather tracker readings collected were not merely tasks assigned by the teacher, but student-led and student-generated data that directly served their inquiry. The process of synthesising these diverse data sources also required students to interpret evidence that they had gathered, rather than working with pre-selected secondary data provided by the teacher. For example, temperature readings collected helped them to verify whether areas with greater human modification in the nature park were indeed warmer, grounding their conclusions in data rather than relying on secondary information or subjective impressions. Overall, the GI design shifted students from passive observation to active, student-directed investigation, encouraging them to take ownership of the inquiry and reflect on their responsibilities as stewards of the environment.

Fig 8. Students' qualitative data collected at Dairy Farm Nature Park, accompanied by heat maps and graphs generated by the teacher based on student-collected data

Another example that showcases how fieldwork can promote student agency comes from a Secondary 2 GI I facilitated, where students examined real-life sustainability challenges and applied their understanding of environmental issues to design sustainable solutions. In the final stage of the investigation, students were tasked to design a neighbourhood that balances social inclusion, environmental quality and liveability. Crucially, they were given full autonomy over the platform used to create their prototype on—the prototype could be a physical model, a hand-drawn blueprint or one that is developed digitally. This approach shifted the GI from one that is teacher-directed to one that emphasised student agency and creativity. The result was a wide variety of prototypes that reflected students' interpretations of sustainable neighbourhoods (Fig 9). This task demonstrates how promoting student autonomy and not limiting their creativity can cultivate greater ownership over their learning, and evolve GI beyond procedural skill acquisition. It enables learners to develop awareness of community needs and environmental considerations when justifying their design decisions, helping them to become more thoughtful designers of a sustainable future.

Fig 9. Students' neighbourhood prototype artefacts

Conclusion

While the Singapore Secondary Geography curriculum provides a strong conceptual foundation for sustainability education given its interdisciplinary nature and focus on human-environment interactions, this potential is limited by its utilitarian framing of nature, coupled with narrow representations of sustainability strategies. Furthermore, the implementation of inquiry processes in teacher-directed ways inevitably position students as passive recipients of knowledge rather than active learners. Classroom-based examples presented in this paper illustrate how pedagogical design can broaden and deepen the curriculum's intent. By incorporating systems-thinking, game-based learning and facilitating student-directed fieldwork, students will be better equipped to evaluate the environmental, economic and social dimensions of sustainability, recognise unequal impacts and come up with informed and ethical solutions to sustainability challenges.

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The Effectiveness of Thinking Anchors in Enhancing Singapore Students' Responses to Geography Data Response Questions

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Abstract

This article examines the impact of structured thinking anchors on Singapore students' ability to respond effectively to data response questions (DRQs) in geography. Through a seven-week action research study using the OHLA (Overall, Highest, Lowest, Anomaly) thinking anchor with Secondary 1 Express (G3) and Normal (Academic) (G2) students in 2022, this research demonstrated significant improvements in student performance and confidence levels during school-based assessments. The findings reveal that thinking anchors serve as effective scaffolding tools that reduce conceptual errors and enhance the quality and structure of student responses to skills-based geographical questions simultaneously.

Introduction

Geography education at the secondary level requires students to develop sophisticated analytical skills, particularly in interpretating and describing data presented in various formats such as graphs, tables and maps. The three main Assessment Objectives (AOs) listed in the 2021 Lower Secondary Geography Teaching and Learning Syllabuses all require students to exercise reasoning in their demonstration and application of geographical knowledge during assessment. For instance, under AO1: Knowledge, students should be able to "demonstrate knowledge of geographical data types, skills and techniques"; under AO2: Critical Understanding and Constructing Explanations, they should be able to "apply geographical knowledge to perform analysis and produce explanations"; and under AO3: Interpreting and Evaluating Geographical Data, they should be able to "apply geographical knowledge to observe patterns and deduce relationships" as well as "draw conclusions based on evidence" (Ministry of Education, 2021). However, educators frequently observe that students struggle to write good-quality answers for DRQs. Students may be more concerned with regurgitating facts and content knowledge without any reference to geographical concepts (Paulsen & Kolstø, 2022; Sukimi et al., 2018) or have failed to achieve higher-order reasoning such as comparing trends for more complex data sets involving two or more variables (Ong & Arulushamaheswary, 2018). The responses produced by these students often lack critical thinking, fail to address the question requirements, and generally show poor understanding of command words and question focus.

The challenge of helping students to articulate their geographical understanding more effectively has piqued great interest in structured approaches for academic writing. Wray and Lewis (1997) pioneered the

concept of writing frames as scaffolding tools to help students organise their thinking and produce more coherent, extended writing. Their work showed that providing prompts, connectives, and organisational structures helps learners to develop critical literacy skills. More recently, writing frameworks have emerged as pedagogical tools that help students to enhance both the clarity and quality of their responses (Spÿcher, 2021). For the purposes of this study, such structured frameworks are termed "thinking anchors" – systematic, acronymic devices that help students remember key analytical steps while maintaining flexibility in application. This terminology reflects their function as cognitive organisers that support disciplined approaches to problem-solving while grounding students' analytical thinking.

The theoretical foundation for using structured writing approaches in education is well-established in academic literature. Wood, Bruner and Ross (1976) first introduced the concept of *scaffolding* to describe the contingent, temporary support that enables learners to accomplish tasks beyond their current independent capability. Their work demonstrated how expert guidance can structure a learner's performance through modelling, reducing complexity, and maintaining direction, until the learner gains sufficient mastery to take over and complete the task independently. This instructional mechanism provides a powerful rationale for implementing structured writing tools that break down disciplinary tasks and make cognitive processes visible.

Vygotsky's (1978) sociocultural theory further strengthens this justification through the concept of the Zone of Proximal Development (ZPD), which delineates the space where learning is optimally supported by skilled assistance. Scaffolding occurs within this zone as it connects the learner's current and potential capabilities by organising thinking and shaping higher-order reasoning. Subsequent scholarship such as Hammond and Gibbons (2005) has shown how scaffolding can be applied more systematically to support academic learning. Their model identified designed-in features such as task sequencing and mediational texts as well as interactional scaffolding that provide structured yet flexible supports that enhance students' engagement with challenging curriculum content. As these forms of support are gradually withdrawn, students would have internalised the cognitive routines needed for independent writing and thus a transfer of responsibility from the teacher to the student is achieved. Gibbons (2002) emphasises that scaffolding must be carefully designed to support both content learning and language development simultaneously.

Scaffolding in Geography Education

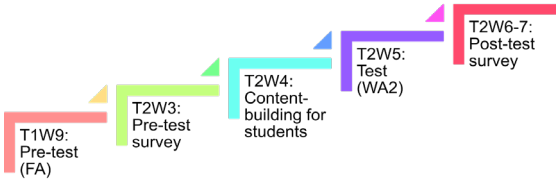
Geography education research has increasingly recognised the importance of explicit scaffolding in developing students' analytical and interpretive skills, particularly in responding to DRQs. Lambert and Morgan (2010) suggest that effective geography teaching requires systematic attention to students' ability to interpret spatial data, recognise patterns, and construct evidence-based explanations, all of which are processes that align closely with the forms of scaffolded support described by Hammond and Gibbons. Heffron and Downs (2012) further identify data interpretation as a core component of geographical thinking, arguing that without the use of explicit instruction in analytical frameworks, students often struggle to move from descriptive to analytical responses. Similarly, Roberts (2013) foregrounds the central role of *thinking geographically*, which requires students to

apply concepts such as place, scale, and interdependence in their written explanations. Roberts posits that structured approaches to geographical thinking can significantly improve students' performance on data interpretation tasks, echoing the larger principles of scaffolding and the gradual release of responsibility. Within this context, the application of thinking anchors in DRQ instruction helps students make disciplinary reasoning visible, organise complex information thoughtfully, and internalise geographical concepts and themes like scale and sustainability. As these supports are withdrawn over time, learners develop greater independence and sophistication in handling DRQs, illustrating the powerful synergy between sociocultural learning theory and geography-specific pedagogy.

Methodology

This study employed a pre-post intervention design to evaluate the effectiveness of thinking anchors in improving student learning outcomes and confidence levels in answering DRQs. The research was conducted at Canberra Secondary School in 2022 with the entire Secondary 1 Express (now G3) and Normal (Academic) (now G2) student cohort over a seven-week period, commencing in Term 1 Week 9 and ending in Term 2 Weeks 6 to 7.

Figure 1: Timeline showing the research project taking place over two terms



The cohort comprised 215 Secondary 1 students across six classes: four Express stream classes (1E1-1E4) with 137 students in total, and two Normal (Academic) classes (1N1-1N2) with 78 students in total. Conducting a census ensures that all variability within the cohort including differences across stream, class, and individual ability is captured, providing better coverage than sample surveys due to greater inclusivity in population extent (Kish, 1979). This approach eliminates sampling error and allows for more precise evaluation of the thinking anchor's effectiveness across all students in the cohort. The census design ensures that the study's findings accurately reflect the outcomes for the entire Secondary 1 population within this school context.

The thinking anchor employed in this study was the OHLA framework, specifically designed for map and graph DRQs. OHLA stands for:

- **Overall**: Identify the overall trend or pattern – from first to last year (graph); even or uneven distribution (map)

- **Highest**: Identify the highest trend or pattern – increase or decrease (graph); highest concentration (map) [Tip: this follows Overall]

- **Lowest**: Identify the lowest trend or pattern – increase or decrease (graph); lowest concentration (map) [Tip: this follows Overall]

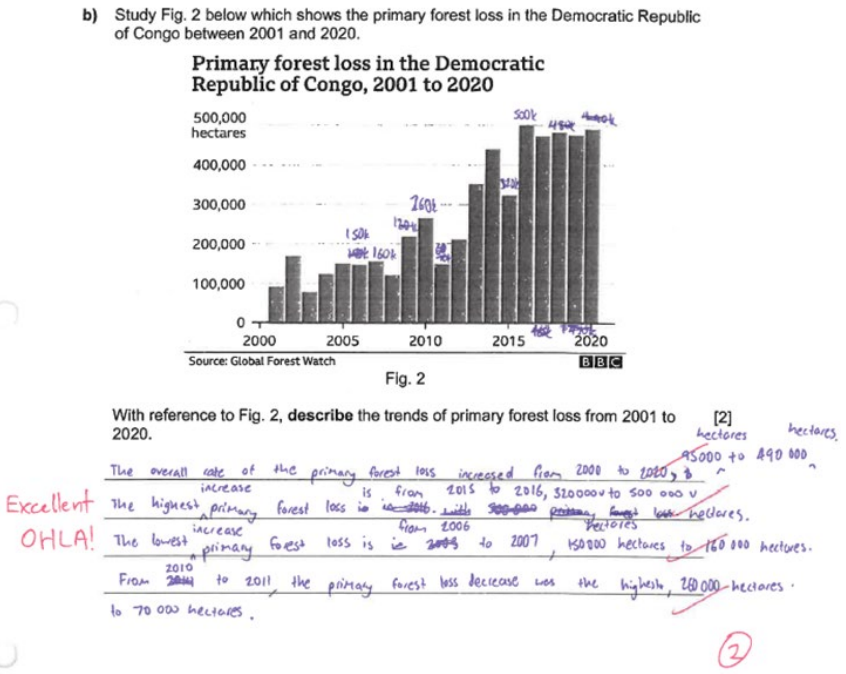
- **Anomaly**: Identify any unusual patterns or outliers [Tip: this is the *opposite of* Overall]

This framework provides students with a systematic approach to analysing graphical data while ensuring comprehensive coverage of key analytical elements. Furthermore, the OHLA acronym is memorable and easy to recall, making it

a catchy mnemonic that helps students internalise the structure and apply it consistently when answering DRQs.

For example, Figure 2 illustrates how a student successfully applied the OHLA thinking anchor to analyse primary forest loss trends during Weighted Assessment 2. The response systematically covers: overall increasing trend from 2001 to 2020 (Overall), highest increase from 2015-2016 jumping from 320,000 to 500,000 hectares (Highest), lowest increase from 2006-2007 rising modestly from 150,000 to 160,000 hectares (Lowest), and the anomalous decrease from 2010-2011 declining from 260,000 to 70,000 hectares (Anomaly). This exemplar shows how the framework guides students to provide comprehensive trend analysis with specific numerical evidence from the graph.

Figure 2: Student response showing the application of the OHLA thinking anchor to analyse forest loss trends with systematic coverage and numerical evidence



This study employed a form of methodological triangulation to strengthen the validity of its findings regarding the impact of the OHLA thinking anchor on student learning. Multiple sources of data were collected:

1. **Pre-test Performance**: Formative Assessment 2 (FA2) administered before OHLA instruction, featuring a 3-mark graph description question

2. **Post-test Performance**: Weighted Assessment 2 (WA2) conducted after OHLA instruction, featuring a 2-mark graph description question

3. **Pre-intervention Survey**: Student self-assessment of confidence in answering graph trend description questions via Google Forms

4. **Post-intervention Survey**: Follow-up self-assessment measuring changes in student confidence via Google Forms

By comparing both actual student performance data and perceived confidence levels across pre- and post-intervention time points, the study was able to cross-verify outcomes, providing a more comprehensive and credible understanding of the effectiveness of OHLA (Asogwa, Ede & Hamisu, 2023).

Student responses were evaluated based on two primary criteria, namely the fulfilment of task requirements, including appropriate response length based on points marking and relevance to the question, as well as the provision of correct evidence to support answers. The evaluation process involved systematic assessment of each response against predetermined marking criteria, with task requirement fulfilment measured by direct addressing of question focus and adherence to command word expectations. Evidence provision was evaluated based on students' ability to extract and incorporate specific numerical values, trends, or patterns from the provided data sources into their written responses. Correct evidence was defined as accurate reading and interpretation of data points.

Results and Analysis

The intervention demonstrated substantial improvements in student performance across all participating classes. In the pre-test, 108 out of 215 students (50.2%) scored zero marks on the graph description question. Following the introduction of the OHLA thinking anchor, this number decreased significantly to 74 students (34.4%), representing a 15.8 percentage point improvement.

More striking was the improvement in students achieving full marks. In the pre-test, only 18 students (8.4%) achieved maximum marks, while in the post-test, 77 students (35.8%) scored full marks, a remarkable increase of 27.4 percentage points. This represents more than a four-fold improvement in the proportion of students demonstrating mastery of graph description skills, exceeding the effect sizes reported in Graham and Perin's (2007) meta-analysis of writing strategy interventions for adolescents, where strategy instruction yielded an average effect size of 0.82. The distribution of scores across the middle ranges also showed positive changes. Students scoring partial marks (1-2 points) increased from 89 students (41.4%) in the pre-test to 141 students (65.6%) in the post-test, indicating that even students who did not achieve full marks were demonstrating improved understanding and application of graph analysis skills.

Table 1: Breakdown of Pre-Test (FA2) and Post-Test (WA2) Marks Across All Classes

	FA Pre-test (Total mark: 3m)				WA Test (Total mark: 2m)		
Class Name and Size	0	1	2	3	0	1	2
1E1 (35)	10	12	10	3	7	13	14
1E2 (36)	8	15	6	7	2	9	27
1E3 (34)	28	3	2	1	22	8	4
1E4 (32)	28	4	0	0	24	4	4
1N1 (38)	23	7	6	2	11	12	14
1N2 (40)	11	17	7	5	8	18	14
Total	108	58	31	18	74	64	77

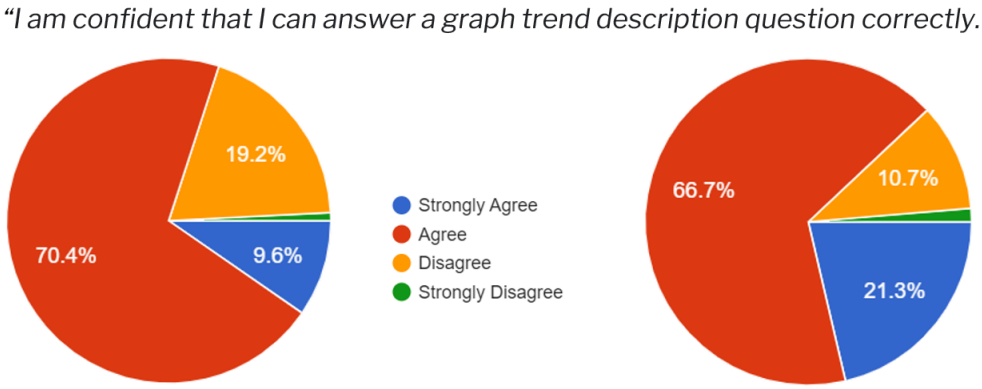
Analysis by academic stream revealed that both Express and Normal (Academic) students benefited from the intervention, although there are varying patterns of

improvement. Express stream classes showed more dramatic improvements in achieving full marks, while Normal (Academic) classes showed significant reductions in zero-mark responses. This suggests that the OHLA thinking anchor was particularly effective in providing basic structural support for students who initially struggled with the DRQ task, aligning with Gibbons' (2002) view that learners develop subject-matter competence when teachers provide deliberate and planned scaffolding.

The survey data also provided crucial insights into student confidence and self-perception of their abilities. In the pre-intervention survey, 80% of students indicated confidence in their ability to answer graph trend description questions correctly. Following the intervention, this figure increased to 88%, representing an 8 percentage point improvement.

More significantly, the proportion of students expressing strong confidence increased substantially and more than doubled from 9.6% to 21.3%. Conversely, the percentage of students expressing disagreement or strong disagreement with their ability to answer such questions decreased from 20% to 12%, indicating that the intervention was efficacious in supporting students who lacked confidence.

Figure 3: Pie charts showing students' perceptions of their ability to answer DRQs before (left) and after (right) OHLA intervention



Effectiveness of Thinking Anchors

The findings strongly support the notion that thinking anchors enhance the quality of student responses to DRQs in geography, aligning with Wray's (1997) foundational writing-frame research, which suggested that scaffolded templates help students produce more coherent and structured non-fiction writing. The OHLA thinking anchor has functioned effectively as a cognitive scaffold, providing students with a systematic approach to graph analysis that reduces extraneous cognitive load while ensuring comprehensive attention to key analytical elements, consistent with the principles of Sweller's (1988) cognitive load theory.

The improvement in performance across different ability levels suggests that thinking anchors address fundamental challenges in geographical skills development rather than simply benefiting specific types of learners. This aligns with Gibbons' (2002) view that well-designed scaffolding provides high challenge and high support, enabling all students to participate more fully in disciplinary learning.

Error analysis conducted as part of the

study revealed important qualitative improvements in student responses. Even weaker students began attempting to use the OHLA thinking anchor when answering DRQs, which improved the overall quality of their responses. Notably, mistakes in post-intervention responses were more frequently attributed to calculation errors and carelessness rather than conceptual misunderstanding or irrelevant answers. This shift in error patterns suggests that the OHLA thinking anchor successfully addressed the core problem of students not knowing how to approach graph analysis in a systematic manner. This is consistent with Vygotsky's (1978) ZPD concept, whereby learners can perform tasks more effectively with targeted scaffolding than they could independently.

The substantial increase in students expressing strong confidence (from 9.6% to 21.3%) indicates that the intervention was especially effective for students who initially felt uncertain about their abilities. The findings also showed that students became more willing to attempt graph description questions following the intervention, thus supporting the idea that strategy instruction can foster motivation, including persistence and self-regulation, alongside cognitive benefits (Pressley & Harris, 2006). Some students who left content-based questions blank during assessments, presumably because they had not studied the material, nevertheless attempted the skills-based DRQ. This suggests that the OHLA thinking anchor provided sufficient scaffolding to make these traditionally challenging questions feel more accessible to students.

The success of the OHLA thinking anchor demonstrates the value of explicit instruction in analytical thinking processes. Rather than assuming students will naturally develop systematic approaches to data analysis, this study suggests that providing clear, structured frameworks can significantly accelerate skill development, supporting Heffron & Downs' (2012) emphasis on the need for explicit instruction in geographical thinking skills.

Limitations and Considerations

Despite the positive results, this study acknowledges key limitations that must be considered when interpreting findings and planning for future project implementation.

A longstanding concern in the literature is the risk of over-dependence on scaffolds. Applebee (1984) warns that writing frames can lead to formulaic responses that inhibit genuine reasoning and independent analytical thinking. Similarly, Hillocks' (1986) meta-analysis highlights that while structured approaches support early skill development, there is a risk of rigidity if scaffolds are not gradually reduced. Pressley and Harris (2006) further argue that scaffolding must include explicit plans for gradual fading to ensure students ultimately internalise strategies rather than remain dependent on them. These concerns remain relevant for the OHLA thinking anchor – although it supports students in organising their responses, there is a possibility that learners may focus on following the sequence rather than engaging in deeper analytical thinking.

Methodologically, the study also reflects limitations commonly discussed in Campbell and Stanley's (1963) framework, such as the instrumentation threat posed by the unequal mark allocations between the pre-test and post-test, as well as the relatively short seven-week duration, which may limit conclusions about long-term retention and transfer.

Furthermore, although existing research strongly supports structured approaches to writing and thinking, there remains limited

discipline-specific evidence for the use of thinking anchors in geographical skills instruction. Graham and Perin (2007) note that much strategy instruction research has focused on general or language-arts contexts, with fewer studies examining subject-specific writing demands. In geography education, Bednarz and Bednarz (2004) have called for more research into pedagogical strategies that develop geographic reasoning, especially skills such as analysing spatial or graphical data. This study directly contributes to this gap by providing empirical evidence on the effectiveness of thinking anchors in geography, but further research is needed to validate and extend these findings across topics, levels, and longitudinal timeframes.

Ultimately, how can educators implement writing frames and structured approaches without fostering an over-reliance on formulaic responses? Students should be exposed to a variety of contexts that emphasise transferable skills and promote analytical flexibility. Central to this process is the teacher's professional judgment regarding the gradual fading of scaffolds, ensuring that learners progressively internalise strategies and develop independence. Ideally, the use of structured writing support should be embedded within a carefully sequenced, multi-year spiral curriculum designed to build and reinforce schema, rather than confined to a single stage such as Secondary 1.

Contemporary Relevance and Success of the OHLA Thinking Anchor in 2025

The longitudinal impact of the OHLA thinking anchor intervention extends well beyond the initial seven-week study period, demonstrating sustained effectiveness in supporting students' geographical analytical skills. Following the success of the initial 2022 research, all Geography teachers in Canberra Secondary School adopted the OHLA thinking anchor as a consistent pedagogical approach, implementing it systematically across all Secondary 1 to 4 geography classes over the subsequent three years. The Secondary 1 cohort who participated in the original 2022 research has now progressed to Secondary 4, completing their national examinations in 2025. Recent results from their Preliminary Examinations provide compelling evidence for the sustained effectiveness of structured thinking approaches in geography education when implemented consistently across the curriculum.

Analysis of the 2025 Preliminary Examination results reveals that the OHLA thinking anchor continues to support student success in DRQs at the critical Secondary 4 level. In the Humanities (Geography) GCE Normal (Academic) Level examination, 76.9% of Normal (Academic) students successfully answered DRQs amenable to the OHLA thinking anchor, representing 10 marks of the total assessment. This performance is noteworthy given that these students represent the same cohort that initially struggled with graph description tasks in Secondary 1, with 50% scoring zero marks in the pre-intervention assessment.

Similarly, Express students demonstrated strong performance across different geographical contexts. In the Humanities (Geography) GCE Ordinary Level examination, 65.8% of students successfully passed OHLA-applicable DRQs worth 8 marks, while in the Geography GCE Ordinary Level examination, 80.6% passed comparable questions, also worth 8 marks. These results reflect the cumulative impact of sustained, school-wide implementation of the OHLA framework, suggesting that the thinking

anchor approach has provided students with transferable analytical skills that remain effective across different examination formats and geographical content areas.

The school-wide adoption and consistent implementation of the OHLA thinking anchor over four years demonstrates several important pedagogical principles identified in the literature. Pressley and Harris' (2006) emphasis on strategy instruction promoting long-term retention appears validated by these results, particularly when thinking anchors are reinforced consistently throughout students' secondary education journey rather than being introduced as isolated interventions.

The variation in performance across different streams and subjects also provides insights into the contextual factors that influence thinking anchor effectiveness. The highest performance in Geography, which students study as a full subject rather than an Elective programme, suggests that students may benefit from more extensive exposure to geographical thinking frameworks, supporting Roberts' (2013) recommendations for systematic skill development across the geography curriculum. The consistent reinforcement of OHLA principles across all four years of secondary geography education appears to have maximised these benefits.

The results obtained from the comparative studies between 2022 and 2025 also address concerns that structured writing approaches may lead to formulaic responses, such as those raised by Applebee (1984). Instead of displaying over-reliance on rigid formats, students appear to have internalised the analytical reasoning embedded in OHLA, applying it flexibly across a range of geographical question types. This pattern aligns with Wood, Bruner and Ross' (1976) conception of scaffolding as temporary support aimed at developing independent competence. The sustained improvements observed over four years therefore indicate that a clear, consistently reinforced analytical framework can strengthen students' capacity to interpret and evaluate geographical data rather than constrain it.

In addition, the 2025 findings highlight the contemporary relevance of thinking anchors for meeting national assessment demands that increasingly prioritise analytical and interpretative skills. The school's long-term commitment to applying OHLA appears to have maximised its alignment with syllabus expectations involving the analysis of patterns, deduction of relationships, and interpretation of geographical evidence (MOE, 2021). These sustained gains across both Express and Normal (Academic) students reflect Gibbons' (2002) view that well-designed scaffolding serves an inclusive function, enabling diverse learners to engage meaningfully in disciplinary thinking. Notably, the particularly strong performance of the Normal (Academic) cohort suggests that systematic and spiral implementation of structured approaches may be more beneficial for students who traditionally face greater challenges with complex analytical tasks, while still maintaining academic rigour.

The success of school-wide, multi-year implementation of the OHLA thinking anchor suggests a few important directions for future research in geography education. Further investigation into how students adapt and refine their use of thinking anchors over extended periods of consistent instruction could yield valuable insights into the development of flexible analytical thinking, while research on how best to sustain their effectiveness across multiple year levels and different teachers would

inform curriculum design and professional learning. Additionally, the variation in performance across examination contexts highlights the need to examine how consistently reinforced thinking anchors transfer across different forms of geographical analysis such as photograph interpretation, map reading, and case study evaluation. Understanding these transfer mechanisms within a sustained, systematic implementation model may contribute to the design of more comprehensive and coherent frameworks for geographical thinking.

Conclusion

This longitudinal study illustrates how thinking anchors, when embedded within a coherent multi-year instructional programme, can fundamentally strengthen students' geographical reasoning. The sustained performance of students over four years shows that the OHLA thinking anchor has become more than a procedural tool and

supported the internalisation of core analytical habits of mind central to geography education. Rather than relying on prescriptive steps, students have developed a stable conceptual schema for organising, interpreting, and evaluating geographical evidence. This aligns well with Weinstein and Mayer's (1983) assertion that strategy instruction yields its greatest impact when reinforced systematically over time.

The findings further suggest that long-term, school-wide implementation plays a significant role in deepening disciplinary thinking. The repeated and consistent use of the OHLA thinking anchor across different teachers, topics, and assessment formats appears to have normalised analytical rigour as part of classroom culture. This is consistent with calls in geography education literature for sustained curriculum coherence, particularly Catling's (2014) argument that meaningful geographical learning occurs when students have structured opportunities to revisit, refine, and extend disciplinary concepts over time. In this sense, OHLA has functioned not merely as a tool for improving DRQ responses, but as a heuristic that shapes how students perceive and engage with geographical data.

Importantly, the study highlights the potential for thinking anchors to support greater inclusivity in geography classrooms. The framework's clarity and predictability have benefited lower-readiness students by reducing cognitive load and providing entry points into complex analytical tasks, while still allowing room for higher-ability students to move beyond description toward more interpretive and evaluative reasoning. However, the pattern of results across ability levels also highlights the importance of differentiation. While the OHLA thinking anchor has proven particularly effective for lower-readiness learners by providing essential scaffolding to support meaningful engagement with DRQ tasks, it may not be sufficient for students who are already operating at higher levels of proficiency. For these learners, more sophisticated analytical frameworks may be necessary to extend thinking beyond description and pattern recognition. This aligns with Ong and Arulushamaheswary's (2018) argument that higher-readiness students benefit from instructional approaches grounded in Bloom's Taxonomy, which foreground higher-order cognitive processes such as evaluation, synthesis, and critical reasoning.

Lastly, the study's longitudinal evidence underscores the importance of teacher agency and pedagogical consistency. The lasting educational benefits stemming from the OHLA thinking anchor are inseparable from the collective commitment of teachers

who adopted, refined, and reinforced the approach over multiple years. This raises important implications for school-level professional development, suggesting that thinking anchors and similar frameworks are most effective when integrated into a shared pedagogical vision rather than applied in an ad hoc manner or in isolation.

Future research may explore how thinking anchors interact with more advanced modes of anaylsis, and how schools can design multi-year curriculum structures that promote the progressive development of disciplinary thinking, ultimately preparing students to engage meaningfully with complex geographical issues beyond the classroom.

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The Paradox of Progress: AI and the Challenge of Teaching Sustainability in Singapore

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Abstract

The rise of AI tools has transformed the educational landscape in Singapore, offering unprecedented efficiency and access to information. This study examines the integration of AI in Geography classrooms, a subject where inquiry-based learning and sustainability education form the core. Interviews with four Geography teachers revealed that while AI supports content mastery, information retrieval, and initial ideation, it is less effective in fostering empathy, ethical reasoning, and emotional connections to sustainability topics. The reliance on AI to process data and present information as statistics can deprive students of opportunities to engage with the moral and affective dimensions of sustainability education, which are essential for fostering empathy and ethical reasoning. The findings underscore the importance of intentional, critical use of AI, guided by educators, to ensure that technological affordances complement rather than compromise learner-centered, context-rich sustainability education.

Introduction

The rise of AI tools has begun to reshape the educational landscape in Singapore. In the *Transforming Education through Technology* Masterplan 2030, the Ministry of Education (MOE) positions Artificial Intelligence (AI) as an enabler of deeper student learning and more effective teaching, signaling the norming of AI-enabled education (MOE, 2023). AI-enabled features are also introduced in the Student Learning Space - Singapore's core digital platform for teaching and learning. These technologies hold promise for increasing productivity and access to knowledge but they have also introduced new challenges, especially for educators who were not trained in an AI-native era but are now tasked with guiding students who are. This article focuses on the teaching of Geography in Singapore, a subject where learning is primarily driven by inquiry and students learn about real-world phenomena. The Geography syllabus prescribed centrally by the Curriculum Planning and Development Division identifies inquiry as the discipline's "signature pedagogy," with teaching and learning organised around an inquiry process that defines the roles of teachers and students (MOE, 2024). However, AI is largely absent from the curriculum document. It does not specify where AI fits within the inquiry process or how it can be used to support teaching and learning.

Beyond content knowledge, the syllabus is aligned with the Ministry of Education's framework for Emerging 21st Century Competencies. In the 2023 Upper Secondary Geography Teaching and

Learning Guide (MOE, 2023), it was articulated that Geography aims to nurture "critical and inventive thinking", "communication, collaboration skills and information skills", "civic literacy, global awareness and cross-cultural skills" as the key competencies. These competencies, embedded and designed to be developed within the content curriculum, then raise a critical question: Can AI truly support the development of these key competencies?

Singapore's education system is underpinned by a strong sense of national mission and social responsibility, and driven by policy initiatives such as the Singapore Green Plan 2030 and the Education Technology Masterplan 2030. Alongside this, the Ministry of Education's narrative increasingly positions AI as a key enabler of deeper learning and future readiness. However, there is still a notable absence of explicit guidance on the positioning of AI within the prescribed Geography curriculum. While the Ministry of Education articulates the desired outcome of students becoming "concerned citizens", teachers must first develop the underlying skills—such as information literacy, perspective taking, and ethical reasoning—that enable students to enact this disposition. Yet how these aims should be reconciled with AI-mediated learning remains largely unarticulated. Left unconnected, these parallel narratives place Geography teachers in a complex position of trying to make pedagogical sense of policy aspirations.

The Promise and Limits of ChatGPT in Sustainability Education

AI tools offer powerful advantages for learning, in particular tools that can break down complex content into digestible segments, allowing students to summarise, organise, and compartmentalise knowledge efficiently. In the early stages of inquiry, AI can spark curiosity by supporting background research and ideation by offering broad overviews of unfamiliar topics or generating guiding questions. In gathering data for inquiry, AI can present multiple perspectives, including stakeholder viewpoints and policy arguments that may lie beyond the students' immediate experience. As Xu (2024) discusses, AI presents itself as a useful aid in presenting reasoning evidence for students to derive at conclusions and provide feedback to guide students in the entire inquiry process.

However, these affordances come with limitations in the context of sustainability education. AI relies solely on patterns within the data it has been trained on to generate a position or stand, without the capacity for ethical judgment or nuanced reasoning. Studies by Kurian (2024) revealed that generative AI often exhibit an "empathy gap," as they lack genuine emotional understanding and can produce inappropriate or superficial responses. As a result, students gain shallow understanding of issues as they are deprived of the moral depth and values-based reasoning that are central to effective sustainability education. AI systems often lack sensitivity to culturally specific contexts, resulting in over-generalised representations that may misrepresent local realities and mute the emotional dimensions of human experiences. When students accept such outputs uncritically, they may engage with sustainability issues at a superficial level, limiting emotional connection and empathetic understanding (Macasawang, 2025). While AI may enhance productivity and streamline aspects of the learning process, its limitations risk undermining the deeper intent of subjects like Geography. Sustainability education meant to evoke empathy, ethical reflection, and a personal sense of responsibility toward environmental phenomena and real-world

issues as emphasised in the 2023 Upper Secondary Geography Teaching and Learning Guide (MOE, 2023) would potentially be diminished.

Methodology

This study examines how Geography teachers in Singapore perceive the affordances and limitations of AI in sustainability education. The primary motivation for this research arises from the absence of explicit positioning of AI within the prescribed Geography curriculum, as well as the broad and largely optimistic narratives surrounding AI in national policy messaging. Existing research tends to be situated in non-Singaporean contexts, leaving a gap in understanding how local educators navigate chatbots within a centrally prescribed curriculum. This study therefore seeks to address this gap by foregrounding teachers' lived experiences and professional judgments, as they are key mediators between AI technologies and classroom practice.

This study is framed as a small-scale action research study aimed at addressing a gap in practice. It seeks to explore the disconnect between the national AI rhetoric and the everyday realities of Geography teachers implementing sustainability education within a centrally prescribed curriculum. Qualitative interviews were carried out to examine 4 Geography teachers' perceptions of the impact of AI on students' sustainability learning, guided by the research question: *How do Geography teachers in Singapore perceive the impact of AI on students' learning in sustainability education across dimensions aligned with 21st Century Competencies?* Participants were selected from mainstream secondary schools to include teachers who were teaching the centrally prescribed Geography curriculum and who represented a range of teaching experience (2, 5, 13 and 14 years of teaching Geography) in order to examine whether perceptions differed according to years of service. Interview questions were deliberately crafted to align with the curriculum's 21st Century Competencies outcomes, eliciting teachers' views on whether ChatGPT supported students' content mastery, information retrieval, perspective taking, and emotional engagement with sustainability issues. Data was analysed using a mixed approach: teachers' responses to each dimension were aggregated quantitatively to identify overall trends, while qualitative analysis of teachers' classroom examples provided deeper insight into how these impacts were observed in practice.

From the Educators: Geography Teacher's perspectives

The interview conducted with teachers from Singapore revealed varied perspectives on the integration of AI in education. While all four participants rated AI highly for supporting certain aspects of learning—such as content mastery, information retrieval and exposure to multiple perspectives—they also highlighted significant limitations. Respondent 1 noted how students can benefit from "a plethora of stakeholder's perspectives as well as being able to customise which aspect of sustainability they are researching on", which aided their understanding of differing viewpoints.

Notably, AI was perceived as less effective in fostering the development of empathy and ethical reasoning related to sustainability issues. Respondent 3 observed that AI's automation of data analysis allowed students to arrive at conclusions prematurely, resulting in "knowledge gaps" where empathetical or human-centred dimensions of the information might otherwise have emerged.

Results also revealed teachers' neutrality in students' emotional engagement with environmental topics. Respondent 2 cited students not knowing "the gravity of sustainability issues", suggesting uncertainty arising from the absence of reliable indicators or measures to assess students' affective response. Other findings include concerns of potential over-reliance on AI which impedes students' learning. The results are summarised in Table 1.

Teacher responses also highlighted potential reasons for the observed limitations of AI in fostering empathy among students. Teachers noted that AI undermined opportunities for deeper engagement, as it largely supersedes students' own analysis of data. Respondent 1 highlighted that "students over rely on the how of things which impedes the emotional aspect of what they are searching for". The presentation of information as statistical figures without accompanying ethical or contextual discussion deprived students' capacity to relate personally to the content. These factors suggest that while AI can efficiently manage and present data, the overriding role denies the opportunity for students to develop empathy particularly when ethical reasoning and human-centered interpretation are absent from the learning process.

Table 1

Aspect	Interview questions	Respondents who agreed / largely agreed
Content mastery	AI tools help students grasp complex sustainability concepts more quickly than before.	2, 4
	Students are able to use AI tools to develop a deeper understanding of Singapore's unique environmental challenges.	1, 3, 4
	AI helps students kickstart inquiry by providing useful background information and guiding questions.	2, 3, 4
Information retrieval	Students' research and reasoning skills have improved through the use of AI tools.	None
Information retrieval	The use of AI in my classroom has increased student productivity (e.g. notes generation, completing written assignments) in sustainability-related tasks.	1, 3, 4
Exposure to multiple perspectives	Using AI has improved my students' ability to explore multiple perspectives in sustainability debates.	1, 3, 4
	Students using AI are more likely to rely on pre-	1, 2, 3

	generated answers than critically evaluate the information provided.	
Emotional engagement	AI tools support students in developing empathy and ethical reasoning around sustainability issues.	None
	When students use AI, they remain emotionally connected to the environmental topics being discussed.	4

The findings indicate a largely uniform pattern across participants, with no notable differences in perceptions based on years of teaching experience. Notably, even the teacher with the fewest years of experience had not undergone formal education in a context where AI was integrated as part of learning, suggesting that familiarity with AI use cannot be assumed based on recency of training. These findings suggest that although AI can enhance knowledge acquisition, its capacity to cultivate the affective and moral dimensions remains uncertain.

Teachers as Pedagogical Gatekeepers in AI-Mediated Learning

Many concerns surrounding the integration of AI in education have been raised in existing research. Uygun (2024), for instance, found that 50% of teachers in her sample believed that AI "may create an ethical gap in the educational setting." Similarly, Chen, Lee, and Lee (2025) highlighted that both teachers and students expressed trust issues with information presented by AI, given its potential inaccuracy and lack of factual reliability.

The absence of clear pedagogical guidelines for the ethical use of AI in schools is another pressing issue. Singapore's Ministry of Education (MOE) has introduced the EdTech Masterplan 2030, which outlines how schools can better leverage technology to enhance teaching and learning (Ministry of Education Singapore, 2024). However, specific strategies addressing the ethical integration of AI into teaching practices remain unspecified, leaving educators without comprehensive guidance on responsible AI use. Based on the findings of this study, the following recommendations are offered for guiding the purposeful and responsible use of AI in the classroom.

Planning for Explicit Affective Checkpoints Within the Inquiry Process

Teachers play a critical role in safeguarding the affective and moral dimensions of sustainability education by intentionally embedding affective checkpoints within the inquiry process. This includes crafting inquiry questions that foreground ethical dilemmas and human concerns, rather than focusing solely on technical or informational aspects of sustainability issues. During the data collection and analysis stages, teachers can scaffold learning by assigning students stakeholder roles, enabling them to interpret evidence through the perspectives of different social groups and to recognise competing interests and values. By explicitly analysing data in relation to its human and societal implications, teachers help students move beyond statistical reasoning to develop empathy, ethical awareness, and a deeper understanding of sustainability as a lived human issue.

Making the Systemic Limitations of AI Explicit to Students

Teachers also need to make visible the systemic nature of how AI generates and presents information, particularly its lack of moral judgment, emotional awareness, and values-based reasoning. Students should be guided to understand that AI is designed to process and reproduce patterns in data, rather than to teach, evaluate ethics, or cultivate empathy. Explicitly teaching these limitations can shape how students approach AI use, encouraging them to engage more critically, exercise greater discernment, and conduct counter-checking rather than uncritically accepting AI-generated outputs. Such transparency supports the development of informed and responsible AI use, aligned with the goals of 21st Century Competencies and sustainability education.

Strengthening Professional Conversations Around AI's Pedagogical Risks

At the school and departmental levels, professional conversations among teachers should deliberately include discussions on anticipating and mitigating the pedagogical limitations of AI. Beyond sharing technical strategies, these conversations should surface observations of how AI use may interfere with learning processes, particularly when students become overly reliant on generative tools. This includes collaborative exploration of AI-resilient or "AI-proof" task design, as well as shared counterstrategies for supporting students whose learning is compromised by excessive dependence on AI. Such professional dialogue positions teachers as reflective practitioners who actively shape AI integration in ways that preserve the integrity of inquiry-based and values-driven education.

Taken together, these recommendations reassert the teacher's role as a pedagogical gatekeeper, ensuring that the integration of AI enhances learning without eroding the affective, ethical, and civic purposes of sustainability education.

Conclusion

The use of AI in education presents significant potential if employed critically and intentionally. The role of educators is therefore important in guiding students to interrogate bias, accuracy, and ethical implications, thereby cultivating higher-order critical evaluative thinking and digital literacy. Ultimately, sustainability education must remain learner-centered and context-rich, with teachers playing a pivotal role in facilitating discussions that connect abstract information to lived realities and nurturing the emotional connections necessary for responsible, empathetic citizenship.

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