Examination of Climate Change Conceptualization within Upper Secondary Victorian Curriculum

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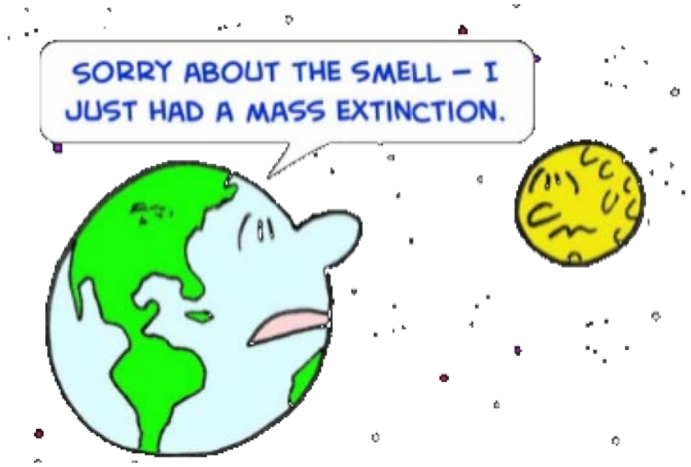
The aims

To examine the conceptualization and integration of climate change (CC) education within the Victorian Certificate of Education (VCE) in the state of Victoria, Australia.

Specifically, to identify and describe potential gaps between

- the *nature of climate change* and its representation within the curriculum;
- the scope of CC as it is understood by the scientific community, and the scope of CC present in the curriculum; and,
- what may be regarded as ‘best practice’ curriculum integration, and the current approach to integration.

Background



The obvious: Climate change is the most major threat of our time, posing unprecedented challenges to humanity (Jamieson, 2014).

The less obvious:

- Very scares research examined the uptake of CC education in curriculum documents across the globe (Læssøea, Weeth Feinsteinb & Blum, 2013).
- Evidence suggest that in primary and middle schools, when CC appears it is mostly integrated within sustainability education.
- Often voluntarily introduced as a cross-curriculum topic, subject to teachers' discretion (Dawson and Carson, 2013).
- In the upper secondary schools, most studies advocate cross-curriculum integration as 'the best-practice' approach, with no evidence for its success (Arnould, 2013).
- The OECD (2018) has expressed concerns that curriculum reforms suffer from time-lags between the recognition that a change is needed to the actual implementation.
- For some major paradigm shifts and scientific discoveries, the time lag between discovery and implementation in school curricula may span over many generations.

Examples for time-lag between discoveries and integration in school curricula

Paradigm shift

Einstein published his General Theory of Relativity in 1915. His equations 'did away with Newton's theory of gravity and replaced it with curved space and warped time' (Blair et al., 2016).

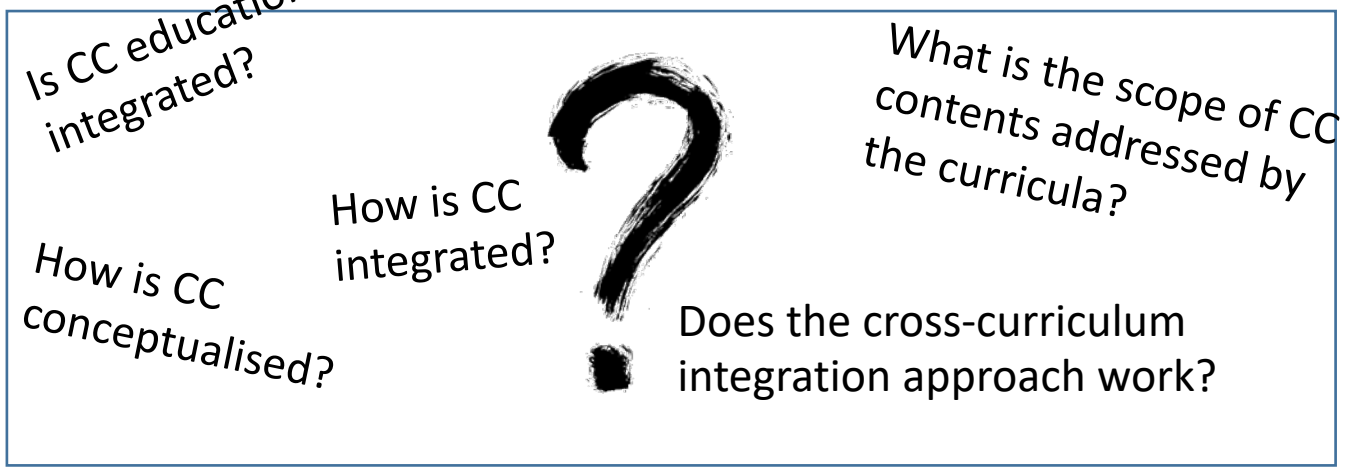
Charles Darwin published his seminal book, the 'Origin of species by means of natural selection' in 1859 (Masci, 2014).

The earth natural greenhouse effect was discovered in 1824 by Joseph Fourier. Fast forward, in 1961 the scientific community was ready for a paradigm shift with Charles David Keeling's production of the Keeling Curve showing the progressive build-up of atmospheric carbon dioxide (Le Treut, et al., 2007).

Curricula responses

This fundamental paradigm shift is still partially reflected in F-10 curricula in Australia, 104 years later. the majority of students who do not study physics in Years 11-12, remain with physics knowledge no more recent than 1865. (Blair et al., 2016; Dacey, 2012).

It took 122 years, until in 1981 the National Center for Science Education was founded in the USA, with the aim of advocating the teaching of evolution in public schools. (Masci, 2014).



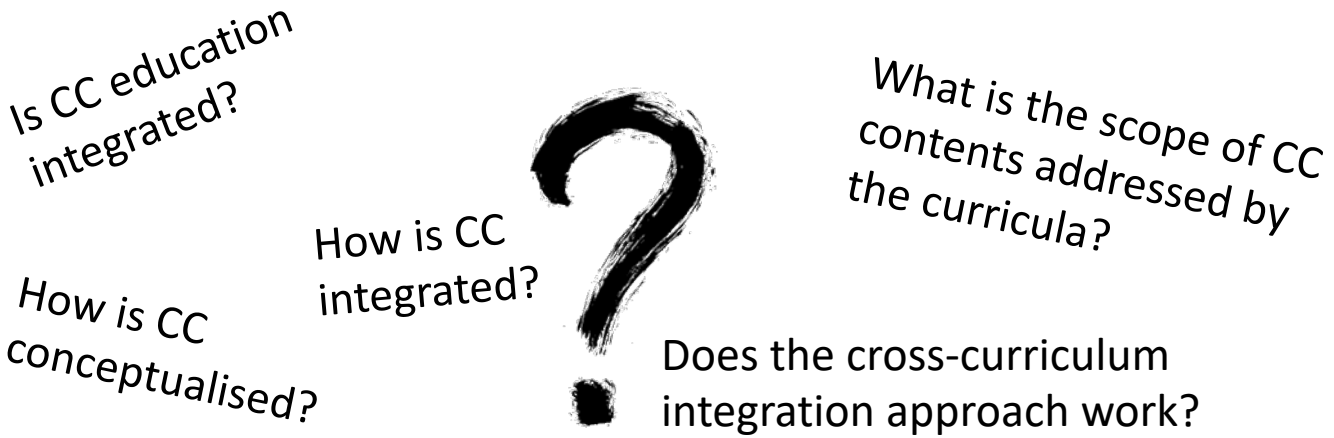
Research questions

The study focuses on **Victorian upper-secondary curriculum**

The questions:

1. How is climate change conceptualised?
2. What is the scope of CC content knowledge present in the study designs identified as addressing CC?
3. How is the *cross-curriculum integration* approach, addressed by the examined study designs?

Methods



Preparatory stages

Is CC integrated within the upper-secondary curriculum?

Identification of key CC terms, and applying these terms for identifying CC within the VCE study designs

How is CC conceptualised?

Identification of essential characteristics of the *nature of CC*

What is the scope of CC contents addressed by the curricula?

Framing the scope of CC in terms of associated content knowledge

Data sources: VCE STUDY Designs

The Structure of the Study Designs

- Introduction – includes: Rationale, Aims, and Structure, and additional administrative parts
- Assessment and Reporting – Includes: Satisfactory Completion, Authentication, and Levels of Achievement.
- Units of Study - The contents are organized within four units, followed by specification of the assessment requirements.
- Areas of Study - Each unit comprises 1-3 sub-themes, including: a short description, specification of outcomes, key knowledge and key skills.
- Advice for Teachers - includes: Introduction and Administration; Developing a Program; and, **Teaching and Learning Activities.**

Is CC integrated within the upper-secondary curriculum?

Identification of key CC terms, and applying these terms for identifying CC within the VCE study designs

CC being vastly broad could potentially be connected to any topic in the curriculum. The challenge is to identify key terms that may unambiguously identify study designs which address CC.

Data sources consisted of the four volumes of the IPCC Fifth Assessment Report (IPCC, 2014) :

- Mitigation of Climate Change
- The Physical Science Basis
- Impacts, Adaptation and Vulnerability Part A
- The Synthesis Report

Key Terms: climate change, global warming, greenhouse gases, and carbon dioxide.

Climate change identified in 10 study designs out of 94 examined, including:

- Australian and Global Politics
- Environmental Science
- Physics
- Economics
- Agricultural and Horticultural Studies
- Geography
- Systems Engineering
- Chemistry
- Outdoor and Environmental Studies
- Food Studies

How is CC conceptualised?

Identification of essential characteristics of the *nature of climate change*

Data sources: Literature review

Four characteristics of the *nature of CC* identified,
consisting of:

- Complexity and multiple systems interactions (U.S. Global Change Research Program, 2009)
- Cross-disciplinary approaches (including multi-inter-trans) (Bacon et al., 2011)
- Inherently involves human action (Anderson, 2012)
- Future oriented and uncertainty (Deser et al., 2012)

- The four characteristics were used for identifying the conceptualization of the *nature of climate change* within the study designs
- Other expressions of conceptualisations also examined

Table 2. Climate change conceptualization, by the ten VCE subjects, the *Nature of CC*, perceptions and misconceptions

VCE Study Designs	Nature of CC: Complexity and multiple systems interactions	Nature of CC: Cross-disciplinary approaches	Nature of CC: Inherently involves human action	Nature of CC: Future oriented and uncertainty	Overall perceptions	Misconceptions or misalignment with conventions
Australian & Global Politics	+	+	+	-	CC is a **human crisis**	
Environmental Science	+	+	+	-	CC is an outcome, requiring behavioural, ethical and technological responses	• The enhanced greenhouse effect perceived as a cause of CC rather than forms part of CC processes. • Astronomical and solar systems presented as responsible for CC
Physics	+	+	-	±		Reference to CC as *climate science* or *enhanced greenhouse effect*
Economics	-	+	+	-	CC is an outcome of economic growth	
Agricultural and Horticultural Studies	+	-	+	-	CC is primarily a **problem of management**	
Geography	+	+	-	-	CC is a **cause, a process, an outcome.** It is human induced	
Systems Engineering	+	+	-	-	CC is a problem that requires **technological fix**	
Chemistry	-	+	-	-	CC is a problem of technological efficiency	
Outdoor and Environmental Studies	-	-	-	-	CC is a cause	• CC is a natural change • It is a question of debate whether humans caused CC or it is a natural process.
Food Studies	+	-	-	+	CC is an outcome state forming environmental risk	

+ indicates characteristic present; - indicates characteristic absent; ± indicates partial presence

Climate change conceptualisation

- None of the VCE study designs presents a complete conceptualisation of the *nature of CC*.
- Australian and Global Politics and Environmental Science represent three characteristics; and Outdoor and Environmental Studies has no representation.
- Most study designs present CC conceptualization as either a cause or as an outcome, or as a problem of management, or technology. Only Australian and Global Politics presents CC as a crisis of humanity.

Climate change conceptualisation

- Two study designs present clear misunderstandings regarding CC.
- The misconceptions in Environmental Science include:
  - Astronomical and solar systems are responsible for CC.
  - The *enhanced greenhouse effect* causes CC, rather than forming part of CC processes.
- The misconceptions in Outdoor and Environmental Studies:
  - CC is a natural change.
  - It is debatable whether humans are causing CC or perhaps not.
  - Confusion between public skepticism regarding CC, and the uncertainties inherent to the *nature of CC.*
- The term *climate change* is often concealed under alternative 'code terms'.
  - In Environmental Science: *enhanced greenhouse effect.*
  - In Physics: Climate science. No reference at all to *climate change.*

What is the scope of CC contents addressed by the curricula?

We asked:

How do we know whether a student who learned about CC in accordance to the study design in a particular subject, is sufficiently informed about CC?
How would we know if there are 'holes' left unaddressed in the study designs that may role over to holes in students' CC knowledge?

In other words: The mere fact that CC terms such as GHG, or CO_2, are mentioned in a study design is insufficient to convince us that climate change is addressed appropriately.

To identify comprehensiveness in the study designs there was a need to develop a scoping map.

Data sources:

- The IPCC reports, primarily the IPCC Synthesis Report (2014).
- The UNESCO Course for Secondary Teachers on Climate Change Education for Sustainable Development (UNESCO, 2013).

What is the scope of CC contents addressed by the curricula?

PERSPECTIVES:

Science Facts	Humanity: socio-economic structures, networks, ethics and conduct

more science-facts-based ← **Continuum** → more humanity-based aspects of CC

THEMES

Observed changes in the climate	Drivers of CC	Future CC	Risks and impacts	Adaptation and mitigation	Socio-economic	Policy and governance	Ethics

The information under each theme is organised by: Fundamental questions and essential content knowledge.

The scope of content knowledge across the study designs

Table 2. Levels of comprehensiveness of CC themes addressed by the ten VCE subjects

VCE subjects	Science facts ← Continuum → Humanity: Socio-economic structures, networks, ethics and conduct								Sum of Scores*
	Observed changes in climate	Drivers of CC	Future CC	Risks and impacts	Adaptation and mitigation	Socio-economic	Policy and governance	Ethics	
Australian & Global Politics	2	3	1	2	3	3	3	0	17
Environmental Science	3	1	1	1	2	0	0	0	8
Physics	2	1	1	0	0	0	0	0	4
Economics	0	2	0	0	1	0	1	0	4
Agricultural and Horticultural Studies	0	1	0	1	1	0	0	0	3
Geography	1	0	0	1	1	0	0	0	3
Systems Engineering	0	0	0	0	1	0	0	0	1
Chemistry	0	0	0	0	1	0	0	0	1
Outdoor and Environmental Studies	0	0	0	0	0	0	1	0	1
Food Studies	0	0	0	0	0	0	0	0	0

* Comprehensiveness of content knowledge score: 0=no content; 1=minimal content; 2=medium amount of content; 3=comprehensive content

The scope of content-knowledge across the study designs

- Across the ten study designs, CC content themes remain mostly unaddressed by the Victorian VCE curriculum.
- Only the Australian and Global Politics study design addresses CC in a comprehensive way, with a score of 17 out of 24. However, the CC unit is offered as an elective and thus, may not be taught at all.
- Environmental Science received third of the points, scoring 8.
- All other subjects received scores ranging 0-4 points.
- The most commonly addressed theme is adaptation and mitigation, followed by drivers of CC
- None of the study designs addresses the ethics theme.

It is highly unlikely that a VCE graduate is informed about climate change at any sufficient level, if the teaching in class was in accordance to any of the 93 study-designs

CC in Environmental Science

- Contrary to our expectation, CC is conspicuous in its absence from the study design.
- The term *climate change* is rarely mentioned. Aspects related to CC seem to be concealed under the reductionist term *enhanced greenhouse effect*, which is portrayed as a problem of imbalance of gases in the atmosphere.
- The content knowledge lean toward the *science facts* end of the *perspectives-continuum*.
- Some of the underlying science of some CC aspects is incorrect.

Cross-curriculum integration

- None of the study designs addresses cross-curriculum integration in any way.
- The various study designs seem to operate in silos in regard to CC education.
- The study designs provide no indication as to how students may complement their CC knowledge beyond the fragmented pieces of information provided in the various study designs.
- In some study designs there appears to be an unsubstantiated assumption that students have prior knowledge in CC.

Discussing the gaps

Gap between the **nature of climate change** and its representation within the study designs

- Fundamental conceptualization gap and lag prevail throughout the study designs in regard to the *nature of CC*.
- It seems plausible to suggest that the minimization of the CC phenomena within the curriculum could be attributed to alignment with the government of Australia's prevailing political positioning of limiting climate solutions.
- Further research is required in regard to characterising the *nature of CC*, and implementation in text books, resources, teaching and learning.

Discussing the gaps

Gap between the scope of climate change themes and their representation in the study designs

- CC content knowledge implementation lag is expressed through both: scarcity of information, and its anecdotal appearance.
- The CC themes appear in the curriculum mostly in a disorganised and incoherent way; often emphasizing only one or two themes and neglecting the others.
- The most highly addressed theme is mitigation and adaptation, whereas ethics is consistently absent. However, mitigation & adaptation inherently involve ethical decisions of equity and justice, as those who are most vulnerable to CC contribute the least to GHG emissions.
- The finding suggests that the theme is mostly addressed from a technical issue, rather than from a human perspective.

Discussing the gaps

Gap between ‘best practice’ curriculum integration and the existing approach to integration

- Cross-curriculum integration is often promoted in the literature as best-practice for CC education (Anderson, 2012; Arnould, 2013). However, there is lack in evidence supporting this approach.
- Contrarily Bacon, et al. (2011) found major obstacles, when attempting to implement.
- In practice, CC mostly becomes subsumed, fragmented and under-represented, with no real provisions put in place for cross-curricular integration.
- Our founded belief is that the cross-curriculum integration approach should be discarded and replaced by an evidence-based approach.

Conclusion

The complexity of CC and the inseparability of its parts, call for establishing a new curriculum subject dedicated to CC education.

This approach may have multiple gains, by providing a framework for specialization among teachers which in turn, may improve the quality of CC teaching and learning for students.

In addition, by establishing a senior secondary CC subject, more opportunities may arise for rigorous discussions regarding pedagogical models and strategies for successful implementation of CC education.

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Agricultural and Horticultural Studies	+	-	+	-	CC is primarily a problem of management
Geography	+	+	-	-	CC is a cause, a process, an outcome. It is human induced
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Chemistry	-	+	-	-	CC is a problem of technological efficiency
Outdoor and Environmental Studies	-	-	-	-	CC is a cause **Misconceptions**: • CC is a natural change • It is a question of debate whether humans caused CC or it is a natural process. • Confusion between public scepticism regarding CC, and the uncertainties inherent to the *nature of CC*
Food Studies	+	-	-	+	CC is an outcome state forming environmental risk

Further Examination of Environmental Science

Under Area of Study 2, under Category 2, entitled 'Water Pollution', appears the following question: 'Can the Great Barrier Reef be quarantined to alleviate coral bleaching?' (VCAA, VCE Environmental Science Study Design, p. 20). The question presents potential lack of understanding regarding the causes of coral bleaching. The question may suggest that coral bleaching is caused by an invasive species that may be blocked out through quarantining, rather than by environmental stressors, predominantly ocean warming and acidification, as a consequence of CC.

Another puzzling question appears in the title of Unit 3, Area Study 2, as follows: 'Is maintaining biodiversity worth a sustained effort?' (*ibid*, p.24).
We believe that questioning the importance of biodiversity conservation is inappropriate in a VCE study design context, where evidence-based scientific knowledge should be promoted, as opposed to popular media.

Further Examination of Environmental Science

Unit 4, Area of Study 1 appears the following paragraph:

'In this area of study students examine the concepts associated with the use of different forms of energy by human societies. Focus moves from understanding the relationship between the uses of local sources of energy to examining the global impacts of these uses, including consideration of the consequences over short (seconds to years), medium (multiple years to hundreds of years) and long (thousands to millions of years) time scales. Students investigate through field and practical activities the extent, availability, consequences, and alternative forms of energy available while considering the environmental, social and ethical challenges involved' (*Ibid,* p.29).

We question the underlying rational of requesting students to consider the global impact of using sources of energy in time scales ranging between seconds to millions of years. Standard categories of time scales used in similar contexts are:

- Short-term - 15-30 years;
- medium term - 15/30-40/50 years; and,
- long term - 60/70-90 years (based on IPCC synthesis report, 2014, with timeframe ranges depending on context).

No publication discusses energy use projections in time scales ranging from seconds to millions of years. It seems to us nonsensical to request students to predict impacts of energy use a million years from now, or seconds from now.