Climate change education: the problem with walking away from disciplines

Climate Change Education: The Problem with Walking Away from Disciplines

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Abstract: Globally climate change (CC) is scarcely addressed in school curricula, and school graduates are mostly uneducated about climate change. The purpose of this paper is to make a case for conceptualising CC as a discipline, and to further argue why CC should be included in school curricula as a disciplinary-subject. The paper first examines the lack of CC in school curricula globally. The main approach for including CC in the curriculum is identified as the cross-curriculum approach. The problems associated with this approach are discussed in regard to the challenges posed to the integrity of the CC body of knowledge, and to the teaching and learning. The paper goes on to build a case for conceptualising CC as a discipline in its own right. It explains the notions of: disciplines, subjects, disciplinary-subjects, and their roles. Further, it describes the characteristics of CC, qualifying it as a discipline, and the benefits of including CC in the curriculum as a disciplinary-subject. However, curricular resistance issues are identified and discussed. These resistance issues are further addressed by considering evidence derived from curriculum theory, cognitive psychology and philosophy of science for supporting the inclusion of CC as a disciplinary-subject. Finally, the challenges in establishing a CC disciplinary-subject are discussed. The paper concludes by considering implications for further research.

Key Words: Climate change education, curriculum, discipline, subject, sustainability education, climate change

Introduction

Early evidence of climate change (CC) may be attributed to Guy Callendar, who in 1938 showed that the steady rise in temperature over a century is associated with the rise in carbon dioxide (Le Treut et al., 2007). Since then CC research has become well established, with strong cross-disciplinary arguments providing ever increasing evidence. While today it is widely accepted that CC is the most significant threat of our time, mounting evidence suggests that, globally, this burning topic is not well addressed in school curricula, leaving

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school graduates mostly uneducated about CC (Dawson, 2015; Erasmus+ School Education Gateway, 2020). Further evidence suggests that students need to rely mainly on the media as a source of information about CC (Dawson & Carson, 2013; Field et al., 2019). This is particularly worrying in light of the fact that every school graduate of today will be required to deal with the impact of CC in their lifetime, as will future generations.

This paper suggests that the limited conceptualisation of CC by educators is one of the main problems leading to its poor representation in school education. The main purpose of this paper is to build a case for conceptualising CC as a discipline, and to further suggest that CC should be included in school curricula as a disciplinary-subject.

Comparative curricula analysis suggests that the vast body of research constituting CC is largely unacknowledged by school curricula globally (Dawson et al., 2021). In many countries, CC appears in the school curricula in a tokenistic form, commonly fragmented and dispersed among subjects and subsumed as an undefined topic under the undefined notion of *sustainability*; often treated as a *hot potato* thrown around from one subject to another, and owned by none (Eilam et al., 2019; Gough, 2020). In drawing its theoretical foundation from curriculum theory, a case is made as to why, globally, this approach has contributed to the poor assimilation, thus far, of CC education in school curricula.

This current state of affairs seems to be inconsistent with the growing calls by international organisations and treaties, urging improved CC education. For example, the Lima Ministerial Declaration on Education and Awareness-Raising calls for including CC education in school curricula and development plans (United Nations Framework Convention on Climate Change [UNFCCC], 2014). This call has been reiterated in Article 12 of the Paris Agreement (UNFCCC, 2015) and by the Organisation for Economic Co-operation and Development report entitled *Trends Shaping Education 2019* (Organisation for Economic Co-operation and

Development [OECD], 2019). These and other organisations and international treaties, while being influential in shaping policies, have no statutory powers in relation to national curricula, and thus far, have not been successful in instigating wide range implementation. In this respect, the limited national uptake of these international policies may be viewed as representing McKenzie and Aikens's (2021) notion of "immobilities of policy" (p. 313). Among the various factors contributing to this implementation lag, it seems that school curricula play a major role through their ability to determine content delivery and the ways in which issues are conceptualised. This is addressed in what follows.

Climate Change Inclusion in School Curricula Worldwide

School curricula may be broadly defined as "anything that schools do that affects pupils' learning, whether through deliberate planning and organization, unwitting encouragement, or hidden and unrealized assumptions, can all be properly seen as elements of the school's whole curriculum" (Ross, 2000, p. 9).

Examination of various countries' national school curricula and relevant studies reveals two types of approaches to inclusion. The most prominent approach, which was found in most of the countries for which data is available, and is also supported by most educators, is the cross-curriculum inclusion approach. This approach involves subsuming CC under various disciplinary-subjects across the curriculum (Lehtonen et al., 2019; Schreiner et al., 2005). A second less common approach involves creating a non-disciplinary, or inter-disciplinary space within the curriculum, which allows the inclusion of CC education (Lehtonen et al., 2019; Schreiner et al., 2005). No data was found suggesting the establishment of CC as a school-subject in its own right. Within the cross-curriculum inclusion approach there are three main streams. These include: (i) CC subsumed under the notion of *sustainability* or *environmental literacy,* and further subsumed under subjects (double subsumed); (ii) CC

inclusion within one or a few subjects; and (iii) CC dispersed across many subjects. It is important to note that often the boundaries between the three streams are vague. It is not always easy to determine from reading the relevant literature whether CC is double subsumed (e.g., under *sustainability* and under a subject) or only subsumed once under a subject. Also, in the same curricular document, at times CC may appear in both forms. With this in mind, it is still possible to provide examples for the implementation of the three streams, as described in what follows.

Climate Change Subsumed Under the Notions of Sustainability Education or Environmental Literacy

In the first stream CC is subsumed under other notions, such as *sustainability* or *environmental literacy*. These notions may appear as overarching concepts within a subject, such as geography or science, or alternatively, as an overarching cross-curriculum notion. In both instances CC becomes double subsumed; once under the notion of *sustainability* and a second time under the various subjects in which the term CC appears. This approach can be exemplified in countries such as Australia and Israel, each taking a very different approach to implementation.

In the Australian F–10 Curriculum, the notion of *sustainability* appears as a *cross-curriculum priority*. However, the term CC is conspicuous by its absence throughout most of the *sustainability cross-curriculum priority*. The term is absent from the Overview and the Key Ideas (including Key Concepts and Organising Ideas). The term CC appears only twice in the document under the two Learning Areas of Technologies and Languages. CC is particularly conspicuous by its absence from Learning Areas such as Science, and Humanities and the Social Sciences, in which CC would be expected to be found (Australian Curriculum, Assessment and Reporting Authority [ACARA], n.d.). The close-to-absence of CC from the

Australian Curriculum in Years 7–10, and its tokenistic appearance subsumed under the cross-curriculum priority of Sustainability has been raised as a concern by several authors (Dyment et al., 2014; Gough, 2020).

In the Israeli Year 7–9 Curriculum, Sustainability Education appears as an elective non-disciplinary subject, with CC being thoroughly addressed as one of the topics. Within the core disciplinary-subjects, CC is addressed in Geography-Human and Environment, and in Science and Technology (Government of Israel, Ministry of Education, n.d.). In Geography-Human and Environment, the notion of *sustainability* appears as an overarching organising theme permeating all the topics to be learned, whereas, in Science and Technology, the overarching notion is *environmental literacy*. Though CC is subsumed under these two notions, it is still thoroughly addressed from both aspects of conceptualisation and scope of contents covered (Government of Israel, Ministry of Education, Portal for Education Workers. Curriculum Portfolio for Educational Workers. Geography Human-Environment, n.d.; Government of Israel Ministry of Education, Sciences Branch – Science and Technology pre-school, primary school, and middle school, n.d.)

Climate Change Inclusion within One or Few Disciplinary-Subjects

Often, one or two disciplinary-subjects take the lead in including CC topics. In many cases CC is included in geography and science curricula (Dawson & Carson, 2013; Hermans, 2016). This approach may be exemplified in countries such as the USA, UK, Canada, and Indonesia.

In the USA, the Framework for K–12 Science Education (National Research Council [NRC], 2012) emphasises CC education as a central aspect of science education for middle and high-school students. However, this is not mandatory and the guidelines were criticised as vague (Arnould, 2013; Lombardi & Sinatra, 2013). In the UK's middle school curricula, CC is

implicitly addressed under chemistry and geography (Department of Education, 2014). A Canadian survey reveals that the science subjects take the lead in addressing CC in Canadian schools (Field et al., 2019). Finally, in Indonesia CC is addressed in Years 7–9 within the Natural Sciences (Kemdikbud, 2014).

Climate Change Dispersed Across Many Disciplinary-Subjects

The most highly promoted approach for including CC in the curriculum is through dispersion of CC across many school-subjects (Field et al., 2019; Gomes & Panchoo, 2015). In this approach, CC is expected to be addressed in many or all of the curricular subjects, and teachers are expected to demonstrate the capacity to integrate effective CC teaching in their respective subjects. While no evidence can be found for successful implementation of this approach, it continues to be the most steadfast approach reported in the literature and by many educators (Erasmus+ School Education Gateway, 2020; Field et al., 2019).

Examination of school curricula reveals that CC becomes fragmented and dispersed across the various school-subjects, with limited opportunities for integrating the fragments of information into comprehensive teaching and learning (Lehtonen et al., 2019).

For example, examination of the Year 11–12 curriculum in the state of Victoria, in Australia, revealed that in the 10 out of 94 *study designs* in which CC is present, the scope of contents is alarmingly limited, anecdotal, disorganised and incoherent; to the extent that in two study designs, content items were scientifically wrong. The authors concluded that this curriculum is unlikely to produce graduates who are knowledgeable about CC (Eilam et al., 2019).

Climate Change in Inter-Disciplinary or Non-Disciplinary Spaces within the Curriculum

Another less common approach reported in the literature is the introduction of CC into spaces which are non-disciplinary, or inter-disciplinary. In these spaces CC may occupy part or the whole of the spaces (Schreiner et al., 2005). These approaches are often referred to as project-

based, theme-based, or phenomena-based curriculum structures. One example of this approach is the introduction of phenomena-based learning in Finland's 2016 curriculum reform (Finnish National Board of Education [FNBE], 2014). In this approach, a non-disciplinary space was created. Individual schools are expected to use this space by choosing and planning a curriculum for a different phenomenon each year (Lehtonen et al., 2019). This approach presents several challenges to CC education implementation. Since the chosen phenomenon changes at every school year, there is a high likelihood that even when CC is chosen as the phenomenon in one year, there will be no continuation into the next school level. Additionally, it is yet unclear whether teachers choose to occupy this space with CC education, and if they do, in what ways and to what extent. Furthermore, Lehtonen et al. (2019) caution that teachers may not feel confident in doing so. Schreiner et al. (2005) provide an example of the approach's lack of success by describing how the creation of an integrated natural and social sciences inter-disciplinary space within the Norwegian curriculum failed due to teachers' lack of confidence in teaching out-of-field. It seems that the formation of dedicated non-disciplinary or inter-disciplinary spaces, as exemplified in the Finnish model, shifts the focus from the institutional curriculum to teacher autonomous choice. As the intention of this paper is to discuss CC inclusion in the curriculum, it is beyond the scope of this paper to address issues related to teachers' agency in occupying non-disciplinary or inter-disciplinary spaces with CC education. Therefore, I now turn to focus on the challenges involved in implementing CC education through the other curricular approaches.

What are the Problems with Current Approaches to Climate Change Curricular Inclusion?

The limitations of the two predominant inclusion approaches will now be discussed. These are subsuming CC under *sustainability* and the cross-curriculum inclusion approaches. Due to

the similarities between the two cross-curriculum inclusion approaches: the broad dispersion of CC across many subjects and the limited dispersion across one or few subjects, these two forms are discussed together, in what follows.

The Problem with Subsuming Climate Change Under Sustainability

The problem with subsuming CC under *sustainability* stems from the basic theoretical framework of the term, which brings together a broad range of concepts, often loosely related, with diverse and sometimes conflicting theoretical assumptions. The term *sustainable development* was formally coined in 1987, in the United Nations' publication *Our Common Future* (World Commission on Environment and Development [WCED], 1987). Education for sustainable development (ESD) was soon adopted by many educators and some curriculum developers, who were quick to replace the old *environmental education* with the new term, claiming it with a broader and deepening meaning (González-Gaudiano, 2005; Jickling & Sterling, 2017). Further credence was given to the new term by the United Nations General Assembly adopting resolution 57/254 and instigating the United Nations Decade of Education for Sustainable Development 2005–2014 (UN DESD). The United Nations Educational, Scientific and Cultural Organization (UNESCO) was tasked with leading the Decade (UNESCO, 2005). In its International Implementation Scheme (UNESCO, 2004), UNESCO nominated fifteen perspectives comprising the scope of ESD, including: *Socio-Cultural perspectives* – human rights, gender equality, cultural diversity and intercultural understanding, health, and HIV/AIDS; *Environmental perspectives* – natural resources, climate change, rural transformation, sustainable urbanisation, disaster prevention, and mitigation; *Economic perspectives* – poverty reduction, corporate responsibility and accountability, and market economy (UNESCO, 2004, p. 17). Climate change appears as one of the fifteen topics listed. Since then the term ESD has morphed into *sustainability education, education for sustainability* and others.

When considering the problem of subsuming CC under *sustainability*, the above all-inclusive perspectives hold the answer to why this approach is problematic. González-Gaudiano (2005) describes ESD perspectives as "[an] elusive thematic group of issues" (p. 243), made up of various fields of knowledge, each having its own identity and autonomy as a field. ESD provides an empty space of congregation for the various fields, and in turn becomes an "empty signifier" (p. 245). When co-opting these various autonomous fields into this makeshift shared space, they become deformed and obscured. The connections between these fields may go either way—positive or negative—or have no connection at all. For example, it can easily be seen how *market economy* may pull in an opposite direction to *corporate responsibility*; or *HIV/AIDS* may be unrelated to both *market economy* and *corporate responsibility*. Furthermore, there are no rules and regulations that govern the ways in which the empty space is filled, and therefore it can mean different things to different people, with meanings always being transitory and subject to permanent questioning (p. 246). Jickling and Sterling (2017) provide an example of the *empty signifier's* manipulation by describing how the term *sustainability* is used abundantly in advertisements by polluting industries in the service of the neo-liberal market, and to justify continuous economic growth. Selby sums up the problem by stating that ESD "has become part of the problem rather than part of the solution" (Selby, 2010, p. 36). If sustainability is no more than neologism, it seems self-evident that the notion of *sustainability education* is an unsuitable platform for hosting CC education. It does not provide a framework for coherent, comprehensive, knowledgeable and effective CC teaching and learning. Being contextualised and subsumed into other contexts, it becomes particularly difficult to trace how the various parts of CC education have been included in the *sustainability education* process and whether they have been implemented in a cohesive and holistic way. Furthermore from a research perspective, unlike the notion of *sustainability*, which is still undefined 33 years after its first public appearance, the field of

CC is a well-defined and measurable body of knowledge, with typical organising principles. This aspect is elaborated further in this paper.

The Problem with Cross-Curriculum Inclusion

While no empirical study was found that demonstrates successful implementation of the cross-curriculum approach, there is ample evidence suggesting that this approach is not working. Here the limitations of the approach are addressed through consideration of challenges to the integrity of CC as a body of knowledge, and challenges to both teachers and students.

Challenges to the Integrity of Climate Change as a Body of Knowledge

Climate change as a body of knowledge has been developing incrementally over the past century (Black, 2013; Le Treut et al., 2007). The science of CC is well established, and the socio-economic aspects of this body of knowledge have been catching up quickly as well (Intergovernmental Panel on Climate Change [IPCC] Climate Change Synthesis Report, 2014). From a disciplinary perspective, CC cannot be justifiably subsumed under any specific curricular disciplinary-subject. It does not constitute a topic of science, nor of sociology, mathematics or the arts. It draws upon all of these and more, but integrates and contextualises the various fields of knowledge according to organising principles that transcend beyond the traditional disciplinary-subjects. CC is likely the most complex multi-system challenge in human history. The complexity of CC, and the inseparability of its parts, make it almost impossible to effectively teach it through fragmentation. There is a need for a specialised learning environment that allows the development of coherency and connectedness in CC education. Studies have cautioned that the dispersion of CC across the curriculum leads to omission of critical links between the various pieces of information taught in different subjects (Lehtonen et al., 2019). From an organisational perspective, the fragmentation

approach creates challenges in: (i) developing CC curricula that ensures that on the one hand the various CC topics are not repeated in different disciplinary-subjects, and on the other hand, that the various CC fragments are integrated into a whole; (ii) differential resources allocation, as different resources may be required in geography and the arts; and (iii) allocation of adequate time for covering CC appropriately within the already crowded disciplinary spaces (Schreiner et al., 2005; Tolppanen et al., 2017).

For CC education to grow and establish itself, it requires time, curricular space and years of practical implementation for best practice to evolve. This is not possible in an environment that does not promote any form of specialisation and professional ownership. Ross (2000) has commented on how curriculum topics that are not specialised tend to gain low status within the curriculum. Low status topics tend to be elective, often cross-curricular, and they are unbounded and non-classified. This is clearly the case in regard to CC, whether it is subsumed under the cross-curriculum approach (as in the Victorian upper-secondary curriculum (Victorian Curriculum and Assessment Authority [VCAA], n.d.), or double subsumed under *sustainability* and another subject, as in the case of the Israeli middle-years curriculum (Government of Israel, Ministry of Education, n.d.).

Challenges to Teachers and Students

Applying CC education through cross-curriculum approaches is particularly challenging for teachers. Lack of expertise appears to be a prime reason for teachers' reluctance to address CC in their disciplinary-subjects (Lombardi & Sinatra, 2013; Ratinen, 2016). The barrier posed by low content knowledge has been confirmed in repeated surveys in which teachers were asked to identify issues preventing them from teaching CC (Field et al., 2019; Plutzer et al., 2016). Additionally, the literature reports on barriers such as lack of curricular resources,

professional development and support for teaching CC (Field et al., 2019). All these issues impact on teachers' agency and professional identity in relation to CC education.

Concerning teacher agency, when viewed from an ecological perspective (Priestley et al., 2015), the cross-curriculum approaches are not designed for providing the environmental means for supporting teachers' individual efforts. Essential environmental means, including resources, contextual and structural factors, seem to be requisites for the emergence and enactment of teacher agency (Biesta & Tedder, 2007). Furthermore, Biesta et al. (2017) noted that teachers' talk tends to align with policy discourses, that shape their work-environment. This highlights the important role of curricular approaches in influencing teacher agency in implementing CC education.

Concerning professional identity, specialised content knowledge seems to play an important role in what it means to be a teacher and in developing a successful teaching career. Professional identity describes the ways in which teachers perceive themselves as professionals (Avraamidou, 2014; Mockler, 2011). Disciplinary-subject specialisation has been shown to be one of the important factors contributing to the development of this construct (Carlone & Johnson, 2007). When considering this important aspect of teaching, it seems that teachers' reluctance to teach CC outside of their area of expertise is grounded in their perceptions of themselves as professional teachers. From this perspective, the cross-curriculum approach, by which it sets an expectation to teach out-of-field, may be viewed as setting up teachers to fail and is therefore likely to encounter high resistance (Du Plessis et al., 2014; Sharplin, 2014). It comes as no surprise, then, that studies among teachers report that many regard CC education as an add-on, unrelated and beyond the boundaries of their disciplines (Porter et al., 2012; Tolppanen, et al., 2017). This aspect of teacher identity will be revisited in this paper when considering the benefits of establishing CC as a disciplinary-subject.

The challenges to teachers extend to student learning. This was exemplified in numerous studies among students, finding: low content knowledge and conceptual understanding, and misconceptions. Students themselves report in repeated studies that they request and expect to learn more about CC (e.g., Chang & Pascua, 2016; Field, et al., 2019).

In summary, the problems with the current state of CC inclusion relate to all levels of curriculum development and implementation: starting with the inappropriate conceptualisation of CC as a topic of *sustainability*, or a topic of the various disciplinary-subjects, and continuing with the curriculum organisation, the lack of integrity of the field, and the attribution of low status to CC— and finally, by posing unsurmountable challenges for effectively teaching CC. The argument made in this paper is that all these problems relate back to an epistemological flaw in the conceptualisation of CC. Common to the above approaches is that they all reflect a perception that CC is an *issue*, a *topic* or a *phenomenon*, and as such, the main challenge is to find a place for this *issue* in the crowded curriculum. In what follows I make a case for the epistemological conceptualisation of CC as a discipline.

Making a Case for Conceptualising Climate Change as a Discipline

Here I arrive at the main purpose of this paper. Making a case as to why CC should be regarded as a discipline in its own right and why the inclusion of CC as a new disciplinary-subject in the curriculum is an essential and timely move forward.

I begin by describing the terms *discipline* and *subject*, and my use of the terms: *subject*, *school-subject* and *disciplinary-subject*. This is followed by discussing the relationships between the terms *discipline* and *subject*, using various theoretical lenses. In focusing on the disciplinary aspect of CC, I continue to theorise regarding the processes and attributes by which a field of knowledge becomes a discipline and address the important role of disciplines in the human construction of knowledge. The insights drawn from the theoretical discussion

are then applied in outlining the characteristics of CC, which qualify this field as being regarded as a *discipline*.

The Terms Discipline, Subject, and their Relation to Each Other

Discipline

The term *discipline* is understood as specialised knowledge in both structure and purpose (Young, 2013). Disciplines are characterised by the ways in which the knowledge is produced, applied, valued and evaluated, as well as rules and concepts related to governing epistemological principles (Duschl & Grandy, 2013; Young, 2013, 2014). Concepts within a discipline are linked to each other and to their underpinning theories (Ross, 2000; Young, 2013). Scholars who hold and produce disciplinary knowledge are considered specialists. The boundaries of disciplines and their contents are not fixed. They are "always fallible and open to challenge" (Young, 2013, p. 107), allowing new disciplines to emerge and justify themselves (Ross, 2000; Young, 2013, 2014). Disciplines are considered to have reached a level of maturity when they have a discipline-debate (Harland et al., 2006; Young, 2013). Bridges (2006) argues that:

> without discipline, in the sense of a shared language, a rule governed structure of enquiry, something 'systematic'—we lose the conditions that make a community of arguers possible. Further, we lose the basis for the special claim which research might otherwise make on our attention and on our belief (p. 259).

Viewed from this perspective disciplines are not merely representing a redundant technical organisational framework, but in effect, the disciplines themselves form communities of specialist discourse, supporting the development of professional identities (Harland et al., 2006). The learner is initiated into the discourse by obtaining the knowledge and skills relevant to the discipline (Peters, 1965).

Joseph Schwab (1967), in his seminal work regarding the structures of disciplines, laid out a framework consisting of the following three structural aspects: (i) the organisation of the disciplines in relation to their contents and their relationships; (ii) the substantive structure, relates to the essential concepts and principles that guide inquiry (these are not fixed and always incomplete); and finally, (iii) the syntactic structure, relates to the canon of evidence, and ways of establishing proof. In Schwab's (1967) words:

> There is, then, the problem of determining for each discipline what it does by way of discovery and proof, what criteria it uses for measuring its data, how strictly it can apply its canons of evidence, and, in general, what pathway it follows from its raw data to its conclusion (p. 5).

Bridges (2006) refers to the syntactical structure as the "discipline of the discipline" (p. 259), in the sense that this set of rules renders the research outcomes of the discipline "worthy of attention" (p. 267). Some examples of *disciplines* are provided by Schwab (1967) in his explicit mentioning of history, mathematics and biological sciences, as *disciplines*.

Subject

The term *subject* is understood as the selection, sequencing and pacing of contents. Most commonly, *subjects* are derived from *disciplines* (Ross, 2000); however, they can also be non-disciplinary or inter-disciplinary, such as in project-based and phenomena-based subjects.

According to Deng (2015), scholars such as Jerome Bruner (1960) and Joseph Schwab (1964) viewed school-subjects as directly derived from, and organised according to, the structure of academic disciplines. However, Schwab, as well as the Germain Diduktik, did not perceive the development of school-subjects as a simple process of selection and sequencing of

disciplinary knowledge, but rather as a process involving complex considerations. They viewed education as a process of self-formation, cultivating a range of personal and social attributes, and the discipline as a resource for developing intellectual and moral capacities (Deng, 2015). Schwab (1973) posited that the process of developing subjects for the curriculum should involve "five bodies of experiences" (p. 502), including the subject matter, the learners, the milieus (including, families, communities, neighborhoods and so on), the teachers and the curriculum making. In considering the 'translating' of disciplinary knowledge into subjects, Shulman (1986) discussed extensively issues related to the teachers' need to transform their disciplinary knowledge into pedagogical content knowledge. Additionally, the process of transforming disciplinary knowledge produced by experts into *subjects* involves a range of organisational processes such as inclusion in the curriculum, allocation of the subject to teachers who are disciplinary specialists, timetabling, examination, and training courses for teachers (Ross, 2000). Disciplinary knowledge delivered through school-subjects is described by Young (2013) as *powerful knowledge* since it prepares students for successful participation in adult life. When disciplinary knowledge is organised for transmission, Young (2013) states that "there are no countries that have good education systems that do not rely on their disciplinary specialists as sources of curriculum knowledge" (Young, 2014, p. 198). Furthermore, the fallibility of knowledge can only be experienced from within the disciplines. This means that students who do not hold disciplinary knowledge will not be able to experience its fallibility (Young, 2013). Unlike *everyday knowledge*, disciplinary knowledge has generalising capacities. This implies that for cross-disciplinary learning to occur, there needs to be a strong disciplinary-basis as a foundational support for crossing boundaries (Young, 2013). This is because relations between fields of knowledge can only be established through good conceptual understanding of the rules and principles of the disciplines being crossed (De Moraes, 2014). Some

examples for subjects derived from disciplines are provided by Schwab (1967) in his description of Auguste Comte's (1877) hierarchical organisation of subjects, as ranging across sociology, biology, chemistry, physics, and mathematics.

The Use of the Terms: Subject, School-Subject, and Disciplinary-Subject

In this paper I use the term *subject* in three forms: *subject*, *school-subject* and *disciplinary-subject*. The form *subject* is used as a general term to denote any form of organised delivery within the school curriculum, whether it is disciplinary-based or not. The form *school-subject* is used to highlight that the subject is delivered at schools, rather than at other educational settings. The form *disciplinary-subject* is used to denote *subjects* that are derived from *disciplines*. In *disciplinary-subjects* the formation of *subjects* takes into account both the coherence of the *discipline* and the appropriateness of introducing new concepts at students' different development stages. However, in relation to content matter, the difference between *discipline* and *subject* is only in the structure and sequencing of the knowledge, but not in the knowledge contents themselves (Bernstein 1971; Young, 2013).

Approaches to Understanding the Relationships Between Discipline and School-Subject

Studies examining the relationships between disciplines and school-subjects highlight the complexity of these relationships. Two typologies were found, describing these relationships. The first typology, offered by Stengel (1997), describes three types of relationships by which disciplines and school-subjects are "continuous, discontinuous, or different but related" (Stengel, 1997, p. 585). Additionally, within the third type, Stengel (1997) identifies three sub-types, including: "(i) academic discipline precedes school subject, (ii) school subject precedes academic discipline, or (iii) the relation between the two is dialectic" (p. 587). Stengel (1997) adds an additional type suggesting that "there is no stable meaning for either

academic discipline or school subject; the meaning of each concept shifts based on one's assumptions about the relationship between them" (p. 592).

Another typology by Deng and Luke (2008) presents the following five types of perceptions of school subjects. These are: "(i) as disciplinary knowledge, (ii) as practical or instrumental knowledge and skills, (iii) as learning activities, (iv) as learning experience, and (v) as sociocultural action" (p. 7).

Various philosophies of education may be related back to these two sets of typologies. For example, both humanistic education and social reconstructionism reject connection between disciplines and subjects (Deng & Luke, 2008). According to these philosophies, the role of disciplines is to develop knowledge, whereas the role of education is to develop the person (Stengel, 1997). In humanistic education subjects are student-centered focused on students' needs and on human activities. In social reconstructionism, the focus of subjects is on generating social agency (Deng & Luke, 2008). Dewey (1916), himself, in his writing, leans more toward the *different but related* dialectic type of relationship. He maintained that while the starting point of education is the child's experience and interests, there is still a need for disciplinary knowledge to inform the teaching process. According to this view, it is the educators, not the curriculum, that play a major role in guiding the students toward disciplinary knowledge.

The modern-day competence-based curriculum seems to align with Deng and Luke's (2008) type 2 "practical or instrumental knowledge and skills" (p. 7), where *subject* "consists primarily of knowledge and skills justified by reference to occupation, profession, and vocation" (Deng & Luke, 2008, p. 6). Other exemplars of relationships may also be identified in curricula. However, regardless of the diverse ways in which school-subjects may relate to

disciplines, the role of disciplines in informing subjects' development is still prominent, in most formal education settings (Young and Muller, 2010).

The Evolution of Disciplines and their Acceptance Among Scholars

Research has rarely addressed the question of identifying a discipline as it emerges. An early attempt to present criteria for distinguishing a discipline was proposed by Foshay (1961), who proposed three criteria as follows: (i) there needs to be an agreement regarding the domain, or the field of phenomena in question; (ii) there is an agreement among the discipline's members regarding a set of rules governing the creation of knowledge; and (iii) the history of the field is also important. From this perspective, the emergence of a discipline is predominantly based on longitudinal and evolving agreements among its members, in relation to epistemological questions. Shermis (1962) claimed that a discipline is distinguished by its ability to address hugely significant questions and develop the techniques to answer them. Similarly, Phenix (1964) identified disciplines by their productiveness, referring to the extent to which a body of knowledge is capable of producing "visible evidence of ways of thinking that have proven fruitful. They [disciplines] have arisen by the use of concepts and methods that have generative power" (p. 48). In relating these concepts back to CC, it seems beyond doubt that the field of CC is dealing with hugely significant questions, and is highly productive in providing "visible evidence" (Phenix, 1964, p. 48), thus qualifies as a *discipline*.

According to Bridges (2006), disciplines emerge when systems of inquiry emerge and a discipline can only exist with a research basis at its core. Harland et al. (2006) offer a more process-based criteria for recognising emerging disciplines. They identified the following four common themes: (i) the research areas represent new and growing fields of academic

interest; (ii) they strive to gain academic acceptance; (iii) they span traditional academic boundaries; and (iv) they involve scholarship that engages with, and changes, practice. It seems that CC research has by now surpassed these four thresholds of acceptance as a *discipline*. All four criteria are clearly demonstrated by the periodic reports published by the IPCC, a leading and most trusted body of the United Nations created to assess the science related to climate change. The IPCC asserts that:

> Thousands of people from all over the world contribute to the work of the IPCC. For the assessment reports, IPCC scientists volunteer their time to assess the thousands of scientific papers published each year to provide a comprehensive summary of what is known about the drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks (IPCC).

Disciplines emerge and morph over eras. From a curriculum organisation perspective, it is a long held tradition in academic institutions to organise departments by disciplines, suggesting that while disciplines may not necessarily reflect the ways in which reality is organised, they are clearly reflections of our perceptions and experience of reality (Bridges, 2006). As early as the Greek Period, Aristotle organised knowledge into three disciplines: "the theoretical, the practical, and the productive" (Deng & Luke, 2008, p. 3), each of these representing different forms of inquiry and production of truth (Deng & Luke, 2008). In medieval times, the disciplines constituted the Seven Uberal Arts. These were divided into the *quadrivium* that included: music, astronomy, geometry and arithmetic; and the *trivium* that included: grammar, rhetoric and philosophy or logic (Holmes & McLean, 2019). In later times, processes of erosion in Christian theology led to the development of *religious studies* as a discipline, which further morphed into *cultural studies* (Turner, 2006).

The history of science provides additional examples of the ways in which disciplines emerge and morph. Often these processes occur as knowledge expands. With the growing understanding of phenomena, new connections are made that necessitate the merging of two or more disciplines that were previously seen as separate. For example, Goodson (1987) describes how biology evolved in the 19th century from its two separate origins in botany and zoology, with the discovery of genetics. Similarly, in the 1950s ecology evolved from its various disciplinary origins in geology, botany, zoology and others. Eugene Odum (1977), has strongly advocated for the founding of ecology as a new integrated discipline. To do so, he identified a set of epistemological principles that underlie the discipline, and allow the disciplinary-whole to be bigger than the sum of its discrete disciplines-of-origin. Odum ended his paper by calling to pursue further merges between the sciences and humanities. The emergent discipline of CC has been following this vision by creating intricate merges between diverse and potentially remote fields, such as political science, anthropology, climatology and others. In these merging fields, the whole is greater than the sum of its parts. Some concepts in CC can only be understood through these merges, while each of the disciplines-of-origin on its own is unable to provide a comprehensive explanation to CC problems. In this sense, "the emergence of CC has caused a paradigm shift in our understanding of the essential inter-relationships between the economy, society, global politics and the natural environment, with implications for sustaining life on earth" (Eilam et al., 2019, p. 5). The characteristics and scope of a CC discipline are presented in what follows.

Recognising Climate Change as a Discipline

Following the footsteps of Odum (1977) in his efforts to establish ecology as a discipline, it is suggested that in order for a body of knowledge to be recognised as a discipline, two requirements need to be met. The first is to present commonly shared characteristics or

epistemological principles, which frame and form the coherency of the discipline. The second is an outline of the scope of contents contained within the disciplinary boundaries. Here, these two aspects are established in regard to CC by drawing on previous work by Eilam et al. (2019).

Climate Change Disciplinary Characteristics

Eilam et al.'s (2019) analysis revealed a set of four characteristics appearing consistently throughout CC research. These are: (i) CC is complex and involves multiple systems interactions; (ii) the study of CC involves cross (multi-inter-trans) disciplinary approaches; (iii) it inherently involves human action; and (iv) it involves a level of uncertainty. These characteristics offer some initial insights into the epistemological nature of CC, which may be followed by further research.

The *complexity and multi-system interaction* permeate CC research throughout all its aspects (Gonzalez-Gaudiano & Meira-Cartea, 2010; Shepardson et al., 2012). These can be exemplified in "the relationships between carbon dioxide emissions and CC indicators and observations"; and "the inherent socio-political-economic complexities associated with mitigation and adaptations to CC, encompassing connections among aspects such as human health, water, energy, land use and biodiversity" (IPCC Climate Change Synthesis Report, 2014, p. 31).

The *cross-disciplinary* nature of CC refers to the integration of multi-, inter- and trans-disciplinary approaches in CC research. According to Choi and Pac (2006) *multi-disciplinary* "draws on knowledge from different disciplines but stays within their boundaries" (p. 351); *inter-disciplinary* "analyses, synthesises and harmonises links between disciplines into a coordinated and coherent whole" (p. 351); and *trans-disciplinary* "integrates the natural, social and health sciences in a humanities context, and transcends their traditional

boundaries" (p. 351). Additionally, cross-disciplinary relationships appear consistently in most published CC education literature (e.g., Kagawa & Selby, 2010; Lehtonen et al., 2019), highlighting the importance of this characteristic not only in CC research, but also in the CC educational process. Unlike any science discipline or non-science discipline, which may be studied independently, CC can only be understood meaningfully through the integration of sciences with non-science disciplines. This characteristic is the one most convincing argument as to why CC must constitute a discipline on its own.

The characteristic of *inherent involvement of human action* seems almost self-explanatory. Humans are involved in CC causes, processes, adaptation and mitigation. The intricate relationships between human actions (or inactions) and CC scientific projections are captured well in a keynote speech given by the IPCC Chair Hoesung Lee, stating that:

> There is no time to lose. The planet's capacity to absorb additional emissions of greenhouse gases without causing severe damage to nature and humans is fixed and the world would soon face the ceiling if emissions rise at the current rate … Global emissions need to be reduced to net-zero … [the achievement of] the net-zero in three decades depends upon the societal capability in managing the transformation. A world characterised by inequality, poverty and lack of international cooperation would make the net-zero transition infeasible (IPCC, 2020).

The fourth CC characteristic relates to the *inherent level of uncertainty of CC projections*. The three characteristics of complexity, cross-disciplinary and human action inevitably lead to the fourth characteristic of CC processes being difficult to forecast. Deser et al. (2012) describe three sources of uncertainty related to future climate change projections. The first source of uncertainty is *forcing*. It "arises from incomplete knowledge of the factors

influencing the climate system" (p.527), such as future trajectories of greenhouse gas emissions. The second source, *model uncertainty*, relates to differences in algorithms used in the various models, thus causing different models to yield different future projections. Finally, the third source, *internal variability*, relates to "natural variability of the climate system that occurs in the absence of external forcing, and includes processes intrinsic to the atmosphere, the ocean, and the coupled ocean–atmosphere system" (Deser et al., 2012, p.527). Together, these forms of uncertainty are inherent for developing CC future projections, and thus form an essential characteristic of CC.

The Scope of Climate Change Contents

While disciplinary boundaries are always permeable and adoptable to new emerging understandings, some outline needs to be drawn as a circumference of the discipline (Young, 2013). Within this outline, it is possible to identify foundational content knowledge, which constitutes the discipline. In deliberating to scope CC contents, Eilam et al. (2019) conducted a thematic analysis of reputable CC publications and their contents. These were organised along a continuum of *CC perspectives*, ranging between: "(i) science facts; and (ii) humanity: socio-economic-political structures, networks, ethics and conduct" (p. 14). Under these *perspectives*, eight *key CC themes* were identified and presented on the continuum ranging from more science-facts-based to more humanity-based (and less science-facts-based) aspects of CC. "The *key themes* are: observed changes in the climate; drivers of CC; future CC; risks and impacts; adaptation and mitigation; socio-economic; policy and governance; and ethics" (p. 14). The thematic contents were then organised by: "*fundamental questions*; and *essential content knowledge*" (p. 14). The *fundamental questions* serve as anchor-points for the subsequent contents of each theme (Eilam et al., 2019). Table 1 presents the CC content scoping map.

Table 1.

Climate Change Content Scoping Map: Perspectives continuum and key themes, ranging from science-facts-based to humanity-based, by fundamental questions and essential content knowledge.

	Science facts ← Continuum → **Humanity: socio-economic structures, networks, ethics and conduct**							
	Observed changes in climate	**Drivers of CC**	**Future CC**	**Risks and impacts**	**Adaptation and mitigation**	**Socio-economic**	**Policy and governance**	**Ethics**
Fundamental questions	What is climate and climate change? What are the instruments and means for measuring the climate in different time scales? What are the observed facts? (This aspect may be taught through an historical perspective tracking the path of data accumulation)	What causes CC?	How are future projections produced? What are CC scenarios? What are the sources of uncertainties in CC projections? What are the future projections of CC?	What are the risks and impacts posed by CC? What characterises risks and impacts distribution?	What are the roles of mitigation and adaptation? What are the means of mitigation? What are the means of adaptation?	What socio-economic processes drive and are impacted by CC?	What is the role of policy? What international, regional and national organisations, agreements and mechanisms are established for dealing with CC?	What is the role of ethics in combating CC? What are some of the relevant ethical dilemmas?
Essential content knowledge	**Explaining climate and climate change.** Climate is the average weather in a given area over a lengthy period of time (Climate Europe). Climate describes the state of the atmosphere, influenced by the oceans, land surfaces and ice sheets. Climate change is a change in the statistical properties of the climate system that persists for several decades or longer—usually at least 30 years' (Australian Academy of Science, 2015). **CC data collection sources and methods of analysis include**: Ice cores drawn from Greenland, Antarctica, and tropical mountain	**Drivers of CC.** Economic growth and population growth drive anthropogenic greenhouse gas emissions growth. These in turn are the dominant cause of warming (IPCC Synthesis Report, 2014, p. 4). GHG are produced through: fossil	**Future projections.** Complex models are applied for developing long-term projections of CC (Collins et al., 2013). Future GHG emissions are determined by complex driving forces, including: demographic change, socio-economic development, and rate and direction of technological change (Nakicenovic et al., 2000). **What are scenarios?** Scenarios are alternative images of the future used to analyse how the driving forces may influence future	**CC risks and impacts.** Risks to *physical systems*, include: rivers, coasts, diminished snow, ice, glaciers, and permafrost cover; *biological systems*, include: desertification, ecosystem losses, mass extinction and reduced biodiversity; and, *human and managed systems*, include: increased fires, cyclone, tsunami, floods,	**The roles of mitigation and adaptation.** *Mitigation* consists of actions to limit the magnitude or rate of long-term global warming and its related effects. Effective mitigation requires require near zero emissions of CO_2 and other GHG by the end of the century (IPCC Synthesis Report, 2014, p. 20). *Adaptation* aims to offset CC effects by reducing the vulnerability of social and biological systems. However, there are limits to its effectiveness (IPCC Synthesis Report, 2014).	**Socio-economic processes.** Continued economic growth and patterns of production, distribution and consumption drive CC (IPCC, 2014). Sustainable socio-economic development is fundamental	**The role of policy.** Projections of GHG emissions depend predominantly on socio-economic development and climate policy (IPCC Synthesis Report, 2014, p. 8). Governments must play a major role in combating CC. Effective implementation of CC policy depends on cooperation at all	**The role of ethics.** Reversing the course of CC requires social transformation of individual and collective assumptions, beliefs, values and worldviews influencing CC responses (IPCC Synthesis Report, 2014, p. 27). Ethical perspectives are inherently involved in

Science facts ← Continuum → Humanity: socio-economic structures, networks, ethics and conduct							
Observed changes in climate	**Drivers of CC**	**Future CC**	**Risks and impacts**	**Adaptation and mitigation**	**Socio-economic**	**Policy and governance**	**Ethics**
glaciers; tree rings; ocean sediments; coral reefs; and layers of sedimentary rocks. This ancient evidence reveals that current warming is occurring roughly ten times faster than the average rate of ice-age-recovery warming (National Research Council [NRC], 2006). **Overall observed changes** indicate that atmospheric, surface, and ocean warming is unprecedented over decades to millennia (IPCC Synthesis Report, 2014, p. 4). Recent anthropogenic GHG emissions are the highest in history (IPCC Synthesis Report, 2014, p. 2). **Sphere-specific observed changes in** *atmosphere* include: enhanced greenhouse effect; carbon cycle disturbances; increase weather variability; precipitation changes; cloud cover changes (UNESCO, 2013). In *ocean* include: changes in ocean temperature and acidification; ocean circulation upheaval; coral bleaching; changes in marine food chains (IPCC Synthesis Report, 2014; UNESCO, 2013). In *land* include:	fuel burning (energy production, industry, transportation); and, land use changes (urbanisation, deforestation, agriculture) (IPCC Synthesis Report, 2014).	emission outcomes and to assess the associated uncertainties (Collins et al., 2013; Nakicenovic et al., 2000). IPCC's four Representative Concentration Pathways (RCP) scenarios include: stringent GHG mitigation (RCP2.6), two intermediate (RCP4.5 and RCP6.0) and very high emissions (RCP8.5) (IPCC Synthesis Report, 2014, p. 8). **The meaning of uncertainty.** CC projections are uncertain for the following three reasons: (i) they depend on scenarios of future anthropogenic and natural forcings that are uncertain; (ii) incomplete understanding and imprecise models; and, (iii) the internal climate variability (Collins et al., 2013, p. 1034). **Future projections of CC.** Changes in surface temperature are projected to rise over the 21st century under all assessed emission scenarios (IPCC Synthesis Report, 2014, p. 10) Intensification of projected extreme events includes: more frequent heatwaves,	drought, malnutrition, diseases spread, economic losses, mortality, and displacement (IPCC Synthesis Report, 2014, p. 14; UNESCO, 2013). **Risks and impacts distribution.** Risks are distributed unevenly. The most disadvantaged people are most vulnerable to be strongly affected by CC. Poor countries are more vulnerable than rich countries (IPCC Synthesis Report, 2014). The risks and impacts vary by geographic regions. For example, some regions are more at risk of wildfires and extreme heat, while others are at risks of floods (IPCC Synthesis Report, 2014).	**Means of mitigation** involve enhancement of technology, behaviour, production and resource efficiency. It requires both upscaling zero-carbon emission electricity generation, as well as reducing demand for energy. Mitigation efforts are required in all sectors. For example: In the energy supply – use of renewables (wind, solar, bioenergy, geothermal, hydro, etc.); in transport – fuel switching to low-carbon fuels; in building – apply integrated renewable energy sources; in industry – use of waste and carbon dioxide capture and storage; in agriculture, forestry and other land use – methane reduction through livestock, reforesting, changes in human diet. **Means of adaptation.** require coordinated actions in 10 categories: (1) human development (such as improved education, health, and nutrition); (2) poverty alleviation; (3) livelihood security; (4) disaster risk management (such as early warning systems); (5) ecosystem management (such as urban green spaces); (6) spatial or land-use planning	to mitigation and adaptation. Climate change processes and impacts involve globalisation, increased socio-economic inequality; inequality in access to resources; unfair distribution of CC risks; increased vulnerability and reduced resilience; urbanisation; rural and urban poverty; gender inequality; displacement; conflict and economic refugees; health impacts, including spread of infectious diseases,	scales, and integrated responses that link adaptation and mitigation with other societal objectives (IPCC Synthesis Report, 2014, p. 26). **International, regional and national organisations, agreements, and mechanisms developed for dealing with CC.** Includes the United Nations Framework Convention on Climate Change (established in 1994) and the yearly Conference of the Parties (COP); the Paris Agreement; the Intergovernmental Panel on Climate Change (IPCC) and its role in assessing the scientific, technical and	evaluation of present trends and conceivably future scenarios (UNESCO, 2013). **Relevant CC ethical issues.** Some CC ethical issues include: intergenerational justice and accountability; lifestyle choices; social justice and unfair distribution of risks; human rights and displacement; traditional lifestyle changes, such as risk to subsistence farming and fishing, vulnerability and resilience building (UNESCO, 2013).

Science facts ← Continuum → Humanity: socio-economic structures, networks, ethics and conduct							
Observed changes in climate	**Drivers of CC**	**Future CC**	**Risks and impacts**	**Adaptation and mitigation**	**Socio-economic**	**Policy and governance**	**Ethics**
*land cover: g*lacier melting; reductions in lake and river ice, soil moisture and runoff, and, permafrost cover (IPCC Synthesis Report, 2014; UNESCO, 2013) and *land biomass:* massive extinction of species; early flowering (UNESCO, 2013). **Observed changes in extreme weather events:** Extremes in warm temperature, high sea levels, and heavy precipitation (IPCC Synthesis Report, 2014, p. 7)		lasting longer; more intense and frequent extreme precipitation; continuing warming and acidification of the ocean; global sea level rise (IPCC Synthesis Report, 2014, p. 10). The risks of abrupt or irreversible changes increase, as the magnitude of the warming increases. Components of the climate system will undergo long lasting changes (IPCC Synthesis Report, 2014, p. 16).		(such as provisioning of adequate housing); (7) structural/physical adaptations in regard to engineering and built environment, technology, ecosystem-based options, and services; (8) institutional adaptations, including: economic options, law and regulation and, national and government policy and programs; (9) social adaptations including educational, informational and behavioural options; (10) spheres of change include: practical, political and personal (IPCC Synthesis Report, 2014, p. 27).	malnutrition and respiratory diseases; and mortality (IPCC, 2014; UNESCO, 2013).	socio-economic information relevant for the understanding of the risk of human-induced CC; UNESCO's role in CCE. The role and actions of Australian national policy and governance in regard to CC.	

Note. From "Climate Change Education: Mapping the Nature of Climate Change, the Content Knowledge and Examination of Enactment in Upper Secondary Victorian Curriculum" by E. Eilam, V. Prasad and H. Widdop Quinton, 2019, *sustainability*, *12*(2), p. 591. (https://doi.org/10.3390/su12020591). Reprinted with permission.

The Benefits of Establishing Climate Change as a Disciplinary-Subject and the Problem of Resistant Curricula

Once CC is accepted as a discipline, two remaining questions need to be addressed. The first is: Why is it important to establish a new disciplinary-subject in the curriculum entitled, Climate Change? The second question is: Why haven't curricula established CC as a disciplinary-subject thus far, and what are the resisting elements in curriculum theory?

In this section I aim to draw a line between making a convincing argument as to why CC is a *discipline*, and making an equally convincing argument as to why it is critically important to integrate CC as a disciplinary-subject in the curriculum. Further discussion leads to the examination of resistant elements in curriculum theory, and to providing counter-arguments negating this resistance.

The Benefits of Establishing a Climate Change Subject in the Curriculum

By establishing CC as an independent subject in the curriculum, benefits will be gained for the disciplinary-subject; the teaching, and the learning. Curriculum theory has demonstrated that curricula are organised by hierarchies and subjects compete to gain status. Core subjects have higher status than elective subjects, and cross-curriculum subjects have the lowest status (Ross, 2000). Within the curriculum hierarchy, these cross-curriculum subjects were described as "not worthy of description, and thus unbounded, non-classified" (Ross, 2000, p. 111). Additionally low status subjects are unlikely to have benchmarks, standards or assessments for evaluating learning outcomes. Educators who are passionate about advancing the teaching of CC should have an inherent interest in advancing the status of CC by including it as a core subject in the curriculum.

The establishment of a CC-subject would carry with it important activities that distinguish curricular subjects and support quality teaching. These include: allocation of time and space

in the school timetable, categories of examination, and accreditation (Ross, 2000). The recognition of CC as a disciplinary-subject would also attract resources and academic scholarship aimed at developing best practices in teaching and learning CC (Harland et al., 2006). By beginning to address CC as a discipline, education scholars may begin researching CC literacy in a more deep and meaningful way, by systematically unpacking the set of skills and knowledge associated with such literacy. In the current state of cross-curricular dispersion, CC literacy becomes meaningless when subsumed under geographic literacy, science literacy and other literacies. Each of these literacies has a set of skills and principles which do not necessarily overlap with CC literacy. For example, the characteristic of model uncertainty due to *forcing* (Deser et al., 2012) is typical to CC and less so to other disciplines. Similarly, the formation of a CC-subject inevitably invites further research related to the epistemic nature of the disciplinary knowledge and to students' knowing, aspects critical for developing quality teaching and learning of CC. In this regard, Sandoval (1916) suggests that research should examine "more carefully at how students' engagement in disciplinary practices affects how they come to understand the nature of particular disciplines" (p. 189).

Teachers are critical in any subject. By establishing CC as a disciplinary-subject, a whole suite of benefits may be gained for developing effective teaching of CC. First and foremost, for teachers to become incentivised to teach CC, this subject needs to be connected with their professional identity (Mockler, 2011; Pedretti et al., 2008). Development of professional identity is reflective of teachers' *competence, performance* and *recognition* (Carlone & Johnson, 2007): where *competence* refers to knowledge and understanding of the disciplinary content; *performance* refers to social performances of relevant disciplinary practices such as ways of talking and behaving; and finally, *recognition* refers to being identified by oneself, colleagues and others, as a climate change teacher (Carlone & Johnson, 2007). In Young's terminology, these teachers would be known as *CC education specialists* (Young, 2013,

2014). Once a community of specialists is formed it follows that various means of support will develop through institutional efforts. These include CC professional development workshops, resources for teaching, and communities of practice, all which are typical to the work of disciplinary professional communities in education (Pedretti, et al., 2008; Wenger, 2011); and are critical for developing teacher agency in CC education (Priestley et al., 2015). Currently these practices are carried out predominantly as bottom-up initiatives, with little top-down complementary support, by institutions and curriculum policy. In other words, while there are abundant of teachers across many countries doing an excellent work in teaching their students about CC, there is an acute lack in formal systems that ensure the provision of CC education to all students.

Repeated surveys found that a critical hindrance for teaching CC is teaching out-of-field. Consistently, teachers report that they are reluctant to integrate CC into their subjects because it is out of their area of expertise (Erasmus+ School Education Gateway, 2020; Lombardi & Sinatra, 2013). If there were a need to choose one reason only for introducing CC as a disciplinary-subject, this would most likely be it. The cross-curriculum approach requires that teachers of various subjects be competent in teaching aspects of CC. For practical reasons, training every subject specialist in CC seems impractical. On the other hand, the choice not to train teachers leaves them feeling vulnerable and lacking confidence in their teaching of CC (Field et al., 2019; Plutzer et al., 2016).

From a student perspective, the introduction of CC as a disciplinary-subject not only signals to students that CC is important (Harris & Burn, 2011), it will also enable the induction of students into the discipline through the acquisition of the set of skills, concepts and rules required for learning and working within the CC disciplinary space (Harris & Burn, 2011; Ross, 2000). These aspects related to the development of epistemic cognition, have been shown to be discipline specific (Hofer, 2000); and students are more likely to develop their

epistemic cognition when the teaching is focused on ideas, arguments and justifications, particular to the discipline. Greene and Yu (2016) assert that "Effective reasoning about complex issues often requires knowledge of the accepted, or normative, epistemic practices in various disciplines" (p. 48); and disciplinary-specific knowledge is critically important in evaluating sources of information and arguing from evidence (Chinn et al., 2011). Ultimately, disciplines provide students with signposts and boundaries that support conceptual development (Young, 2014). Such disciplinary boundaries ensure that students will no longer be required to integrate the fragmented pieces of information by themselves. It ensures more rigour in creating linkages and improved ability to synthesise ideas (Harris & Burn, 2011). In the context of CC, coherent, well organised and evidence-based learning of a CC-subject is the best safeguard against media misinformation (Harris & Burn, 2011).

Harris and Burn summarise their argument against the eradication of disciplinary boundaries in the curriculum by quoting Gardner who stated: "If no single discipline is being applied, then clearly interdisciplinary thinking cannot be at work" (Gardner, 2007, p. 55, as cited in Harris & Burn, 2011, p. 259).

Resistant Curricula and Resisting Educators

Globally, the discipline of CC is confronted by school curricula that are resistant to its inclusion as such. It is suggested here that the reason for this resistance can be largely attributed to the current tendency among curricula developers and educators to oppose disciplines across the board (Biesta & Priestley, 2013; Harris and Burn, 2011). From the early inception of schools, studies suggest that the basic framework for organising curricula was according to disciplines. While this form of organisation shows high resilience over time, surges of theoretical attacks since the late 19th century have been gradually weakening the role of disciplines in curricula organisation (Holmes & Mclean, 2019; Young and Muller,

2010). While thus far these theoretical approaches have limited evidence to support their rationales (Ecclestone, 2013; Young, 2013), it seems that they could be highly influential in creating strong resistance to establish CC as a disciplinary-subject.

Two main surges were highly influential. The first is a surge by the *progressive education* movement beginning at the end of the 19th century, and the second by the *critical curriculum theory* (also referred to as *critical pedagogy* or *critical theory*) beginning in the mid-20th century. Recently, disciplines have been encountering an additional resistance by the *capabilities-based* curriculum trend. The three educational approaches with their resistance to disciplines are described in what follows.

Disciplines were brought into question for the first time in the late 19th century with John Dewey (1902) and successors' pragmatist philosophy (Holmes & McLean, 2019). Dewey's ideas led to the development of curriculum theory known as *progressive education*. The theory with its two streams, the child-centred and the society-centred approaches, puts pedagogy at the centre (Holmes & McLean, 2019; Ross, 2000). The theory postulates that disciplines and their subjects are artificial, and thus needless. In its purest form, the teachers and students develop the curriculum together. Progressive curriculum occupies itself with the question of how learning can best occur, rather than what should be learnt. The aim is for students to learn how to acquire knowledge, and how to understand it (Ross, 2000). An example of the application of the theory can be seen in the Dalton Plan devised by Helen Parkhurst (1887–1958). The program provided every student with the freedom to learn whatever they wished to, by which individual students committed to a form of autonomous project-based learning. Over time it became clear that students were not using their freedom for learning, and the program was abandoned. Nevertheless, the progressive education was influential in many countries, and features of it continue to inform curriculum development in primary schools (Holmes & McLean, 2019).

A second surge on disciplines arrived with the rise of the mid-20th century critical curriculum theory. This theory perceives school curriculum as a political arena in which knowledge taught is selected by those in power, as a means of oppression (Paraskeva, 2011; Young, 2013). Critical theory aimed to undermine the legitimacy of disciplines as sources of truth, and to denigrate them to be no more than a reflection of the social order (Ross, 2000). Accordingly, critical theory ascribes equal value to plurality of knowledge and truths, and thus undermines the role of disciplines in determining factual truths through their rules and principles (Paraskeva, 2011).

A third surge on disciplines is associated with the current trend to move toward capabilities-based curricula, or what has become known as competence-based education (Biesta & Priestley, 2013). This trend appears as a new form of revolt against the traditional disciplinary-based curriculum and signifies a shift towards life-related personal knowledge, pluralistic in nature, in which all knowledge counts equally (Ecclestone, 2013). The approach, which originated in the field of human resource management, focuses on development of specific personal competencies deemed as needed by the society or the economy (Biesta & Priestley, 2013). The starting point and the organising principle for this curriculum approach is specification of the required competencies. Disciplinary-subjects are not perceived as intrinsically worthy (Ross, 2000, p. 117), and there is a tendency to merge and blur disciplinary boundaries, minimising their role by referring to them by new names. For example, in the Australian F–10 curriculum, various disciplinary-subjects are merged, and the curriculum refers to these merges by using the more general term ‘Learning Areas’ (ACARA).

Competencies-based curricula are becoming increasingly universalised. Biesta and Priestley (2013) in their criticism of the Scottish Curriculum, describe how it puts forward the development of four competencies, which constitute both the learning outcomes and the

curriculum organisational framework. These are: “the successful learner, the confident individual, the responsible citizen and the effective contributor” (p. 3). In various countries the trend appears under different names, such as *capabilities*, *skills* or *capacities* (Biesta & Priestley, 2013). The growing emphasis on competencies has been described by Biesta and Priestley (2013) as a change in learning outcomes from “what students should learn to what they should become”. In other words: a shift from a student being “the subject who studies to being the outcome of education” (Biesta & Priestley, 2013, p. 7). The implications for disciplinary-subjects are that competencies become de-contextualised from the subjects of learning. They become the learning outcomes, displacing the learning outcomes of knowledge acquisition.

The resistance to disciplinary-based knowledge seems to have a stronghold among educators, as well as curriculum developers. Recently, when participating in a CC education forum, the conversation addressed the issue of teachers’ professional development in CC. I noted that supporting teachers must include enhancement of their CC content knowledge. One of the educators in the forum, swiftly and resentfully responded to my comment by stating: “Teachers should not be taught knowledge. What knowledge is there to teach? CC is caused by burning of fossil fuels. Full stop”. To my ears this statement sounded equivalent to stating that “Biology teachers should not be taught biology. Because all living things are made of cells. Full stop”. These impressions are echoed in curriculum theory scholarly literature (Lambert, 2011).

In a similar vein, Young (2013) notes that “university colleagues of mine who visit student teachers in schools report something akin to a *fear of knowledge* in the schools they visit—knowledge is either not mentioned or seen as something intimidating and dominating” (p. 107). When addressing this problem among education scholars, Young (2013) describes this as a cause for curriculum crisis. He states: “The third reason for the crisis in curriculum

theory that I want to suggest is the increasingly widespread acceptance among educational researchers of the idea that knowledge itself has no intrinsic significance or validity" (p. 107). Similarly, Ecclestone (2013) notes that in Scotland, England and other countries, there is a "powerful prevailing hostility among researchers, commentators and teachers towards curricula based on traditional subject content, and corresponding enthusiasm for skills or *capabilities* rooted in life-related and personalized knowledge rather than traditional disciplines" (p. 76). Alarmed by these anti-knowledge movements, in recent years there has been a growing critique calling for restoring the role of disciplines in school curricula. However, this critique is not new. As early as the 1970s Schwab cautioned with much foresight against developing curricula that take into account only one aspect, such as students' needs, or society's needs, while overlooking the importance of integrating the four critical aspects, which he perceived as: the subject matter, the learners, the teachers and the milieus. Schwab (1973) explains as follows:

> Despite the educational bandwagons which bear witness to the contrary, neither child nor society nor subject matters nor teachers is the proper center of curriculum. Indeed, the short merry life of many bandwagon curriculums often has arisen from just such over-emphases: the child-centered curriculums of Progressivism; the social-change-centered curriculums of the 1930s; the subject-matter-centered curriculums of recent reforms; the teacher-centered curriculums which may arise from unionism (p. 509).

With these assertions in mind, I now proceed to provide a theoretical based-critique of the anti-discipline movements described above.

Theoretical Arguments Disputing the Negation of Disciplines

The theoretical basis of these anti-discipline and anti-knowledge surges has been strongly and widely critiqued. Here I briefly summarise three lines of critique, coming from three disciplinary lenses. These lenses are: curriculum theory, cognitive psychology and philosophy of science.

In recent years scholars in the field of curriculum theory have been raising their voices against the infringement on the status of disciplines, perceiving it as a threat to knowledge itself. Young (2014) makes this view unequivocally clear by placing the term *knowledge* in the centre of his redefinition of the term *curriculum*. In doing so, he defines curriculum as "basically specialized knowledge organized for transmission" (p. 198). He further clarifies that curriculum knowledge is specialised in relation to its disciplinary specialist sources, and is different from everyday knowledge. These differences are critical, as they create the legitimacy and purpose of schools' curricula. The curriculum should enable students to "acquire knowledge that takes them beyond their experience, and they would be unlikely to acquire it if they did not go to school" (Young, 2014, p. 196). Young claims: "If you want to acquire specialist knowledge, you may start with a book or the internet, but if you are serious you will go to an institution with a curriculum that includes what you want to learn and teachers who know how to teach" (Young, 2014, p.197). By this statement it becomes clear that schools are first and foremost about teaching knowledge, and not competencies in isolation from knowledge. In critiquing the critical curriculum theory, Young (2013) argues that by focusing on the *knowledge of the powerful*, critical theory has neglected to address the question of which knowledge gives more power to the learners, and "what is the important knowledge that pupils should be able to acquire at school?" (Young, 2013, p. 103). Scholars further argue that approaches that present all knowledge as equal, or undermine the role of disciplinary knowledge, as in competencies-based curriculum, put the curriculum at risk of not paying attention to what students learn, and for what purpose (Biesta, 2009; Young,

2013). Priestley and Biesta (2013) identify an "unholy alliance" (p. 3) in the coming together of the three curricular approaches, to undermine the role of disciplines. This is because these approaches stem from opposing socio-economic philosophies. While progressive education and critical theory are derived from a *lefty* worldview which opposes the neo-liberal economy, the competencies-based curriculum is quite the opposite, having its roots in managerial neo-liberal worldview (Biesta & Priestley, 2013). According to Pinar (2019), its aim is to "repurpose schools to being pipelines to the economy" (p. 18). However, regardless of their disparate origins they share the view of "stripping knowledge out of the curriculum" (Priestley & Biesta, 2013, p. 5). Scholars caution that the lack of knowledge specification in the competencies-based curriculum leads to the dumbing down of the knowledge-basis across the curriculum, leaving young people confined to the level of their own experiences (Harris & Burn, 2011; Young 2008).

Additionally, many scholars question the assumption that competencies can be taught at all, when de-contextualised from disciplinary knowledge (Ecclestone, 2013; Young, 2013). This scepticism receives an evidence-based confirmation by the cognitive load theory (Sweller et al., 2019).

Cognitive psychology with its leading cognitive load theory was introduced in the 1980s. It aims to "explain how the information processing load induced by learning tasks can affect students' ability to process new information and to construct knowledge in long-term memory" (Sweller et al., 2019, p. 261–2). The theory differentiates between biologically primary and secondary knowledge (Sweller, et al., 2019). Biologically primary knowledge is knowledge that humans evolved to acquire effortlessly and automatically. These competencies (referred to as *skills*) are generic-cognitive in nature, such as general problem-solving skills or even our ability to construct knowledge. These generic-cognitive skills tend to be more concerned with how we learn, think and solve problems rather than the specific

subject matter itself. This knowledge cannot be taught to most people (Sweller et al., 2019, p. 271). Contrary to these unteachable general competencies, biologically secondary knowledge can only be acquired through teaching. This knowledge is heavily disciplinary-specific. The acquisition of this knowledge, deemed by society as important, requires conscious efforts by the learner and explicit instruction by the teacher.

Sweller et al. (2019) explain that the attempts to teach generic skills (competencies) will always be unsuccessful. They state:

> Such campaigns tend to fail, not because the skills are unimportant but because they are of such importance to humans that we have evolved to acquire them automatically without instruction. The enormous emphasis on teaching general problem-skills last century provides an example … [for the lack of success] (Sweller, et al., 2019, p. 271).

In further emphasising the futile attempts in teaching general competencies, Sweller et al. (2019, p. 272) assert that it is not possible to teach general skills that transcend knowledge-based context. However, these skills may be used successfully to support the acquisition of biologically secondary skills that are content-knowledge specific (Paas & Sweller 2012). Various studies related to epistemic cognition further support this assertion. For example, Greene and Yu (2016) report that when critical thinking is taught as a general skill, it does not lead to gains in epistemic cognition, as compared to targeting discipline-specific critical thinking interventions.

Cognitive load theory provides powerful evidence-based affirmation to what curriculum theorists have suspected, that competencies-based curriculum is the wrong way to go, due to the approach's futile attempts to teach the unteachable. Contrarily, the theory provides

strong affirmation for the important role of disciplinary-based curriculum, due its efficacy in promoting biologically secondary knowledge.

Finally, I now turn to the science philosopher Bruno Latour (2004) for assistance in addressing critical theory's claim that all truths are equal, and thus disciplines are no more than reflections of the knowledge of those in power. In addressing these attempts to delegitimise scientific facts as claims of truths, Latour (2004) argues that "a certain form of critical spirit has sent us down the wrong path, encouraging us to fight the wrong enemies and, worst of all, to be considered as friends by the wrong sort of allies" (p. 231). He explains:

> Like weapons smuggled through a fuzzy border to the wrong party, these are our weapons nonetheless. In spite of all the deformations, it is easy to recognize, still burnt in the steel, our trademark: Made in Criticalland [The land of critical theory] … The question was never to get away from facts but closer to them, not fighting empiricism but, on the contrary, renewing empiricism (p. 230).

Latour in his rich expressive language continues to describe how critical theory failed in its attempts to destroy the truth claims of science. Fortunately, he claims that the theory's weapons of destruction "lay in the dust of our workshop" (Latour, 2004, p. 242). In his effort to restore empiricism, Latour brings the knowledge back to the forefront, and thus the power of disciplines, described by Young as "the best knowledge we have" (Young, 2014, p. 197). This philosophical call should resonate far and wide in the halls of curriculum developers. However, establishing a new CC disciplinary-subject is not without challenges. These are discussed in what follows.

The Challenges in Establishing a Climate Change Subject

Establishing a new CC disciplinary-subject in the curriculum is not a mere technical fix. It calls for a curriculum reform. Schwab in his 1973 publication "The practical 3: Translation into curriculum", addressed the challenges of transforming a discipline into a disciplinary-subject in much detail. Such a process entails a range of professional and administrative activities, including for example: resources development, development of evaluation methods, standards, accreditation, timetabling, allocation of disciplinary-specialist teachers, setting frameworks for developing discipline-specific pedagogical content knowledge, and more (Ross, 2000). Schwab (1973) described the meticulous attention that needs to be given to choosing which pieces of disciplinary knowledge to teach, how these are connected among themselves, to students' prior learning, and to learning in other subjects.

On the backgrounds of these numerous challenges, here I wish to focus attention on some challenges that are specific to developing a CC disciplinary-subject. These relate to: the subject's adaptability to the dynamics of the discipline, its adaptability to local CC conditions, teacher agency, values, and political influences.

Regarding the subject's adaptability to the dynamics of the discipline, CC discipline is unique in its high level of dynamism. While all disciplines are evolving and morphing, in CC these processes may be abrupt. Particularly when it comes to the instability and unpredictability of human systems. For example, a sudden political decision may cause substantial changes to the CC projection models, as well as a wide range of implications across the various CC systems. Similarly, abrupt changes may occur due to crossing thresholds (Le Treut et al., 2007). When developing a CC disciplinary-subject, this dynamism needs to be reflected both in the structure of the subject, and in its representation in students' learning.

Regarding adaptability to local conditions, CC is unique in the sense that while the principles and rules of the CC discipline are general, the manifestations of CC processes are local. CC is

experienced very differently in, for example, desert communities, tropical communities, among those living in poverty, and in rural and urban communities (Laukkonen et al., 2009). A CC disciplinary-subject needs to be responsive to local conditions in its contents and methods. Additionally, the disciplinary-subject needs to be action-oriented in the sense that it equips students in local communities with the knowledge and skills relevant for adaptation and mitigation in their specific circumstances and local communities (Flowers & Chodkiewicz, 2009).

Teacher agency is critical in any education innovation (Leander & Osborne, 2008). Priestley et al. (2015) noted the power of curriculum specifications to act as an enabler of teacher agency. The development of a CC disciplinary-subject needs to provide a generative framework that allows teachers' past experiences with CC, and their professional histories, to interact effectively with the cultural, structural and material resources that are provided by the curriculum and their schools' communities (Priestley et al., 2015). These may be proved challenging in the development of a CC disciplinary-subject, as every teacher of CC has a unique and different personal and professional history with CC, impacting their repertoire of capacities, beliefs and values (Belo et al., 2014). For example, some may have reacted to CC in apathy, others in despair, some have taken action, whereas others inaction. The development of a CC disciplinary-subject needs to be able to frame cultural and structural environments which support the agency of teachers coming from highly diverse dispositions in relation to CC.

The development of subjects is value laden (Young, 2013). In CC education, there is a particular need for the values underpinning the educational intentions to be transparent. The curriculum needs to provide appropriate opportunities to negotiate these values and for reflexivity (Schwab, 1973). The reason for its particular importance in CC education is because scarcely subjects or disciplines in modern history have been exposed to such high

levels of debate and de-legitimising (Jamieson, 2014). It is important that all those involved in the educational process to have access to the CC disciplinary-subject's value-propositions and to be able to develop informed arguments related to these values. Finally, regarding political influences, CC subjects are particularly vulnerable to such influences (Rickinson & McKenzie, 2021). This vulnerability and its impacts need to be considered at the three levels of: the disciplinary-subject, the curriculum as a whole, and the broader educational policy.

Implications for Further Research

The theoretical foundation laid out in this paper has various research implications. First, the gap that was highlighted in this paper, between the highly regarded cross-curriculum inclusion approach and the lack of empirical evidence for supporting this approach, merits further examination. While the theoretical arguments proposed here suggest that the cross-curriculum inclusion approach is not effective, nor can it be, the debate is yet unresolved. Arguably, if this approach is to be further promoted, then the onus needs to be on its proponents to develop theoretically and empirically grounded research that may produce evidence for supporting their claim that cross-curriculum inclusion is the best practice for CC education.

By drawing upon various theories, the paper argues for including CC as a disciplinary-subject in the curriculum. This claim invites a broad range of questions that follow. These may be broadly related to the study of the *nature of CC* as a discipline, the CC curriculum, the teaching, and the learning. In regard to the *nature of CC*, this paper proposes that CC cannot be subsumed under the sciences. It is therefore posited that the study of the *nature of science* is not applicable to CC and a new field of study is required for deepening our understanding regarding the *nature of the CC discipline*. In regard to CC curriculum, further research is required regarding questions related to scaffolding the attribution of high curricular status to

the CC disciplinary-subject. Furthermore, thus far little attention has been given to the selection of appropriate year levels in which CC needs to be taught, and approaches to students' progression across the year levels. In regard to the teaching of CC, further research is required addressing teachers' qualifications to teach CC, professional development in pedagogical content knowledge, resources development, and supporting the development of CC teacher professional identity and agency. Finally, and critically important, is to develop our understanding regarding the cognitive-emotional processes involved in learning CC. How can we best support our students to deal with CC in an effective and realistic way, which on the one hand does not give students a false sense of empowerment, and on the other hand does not drive them to despair? In other words, how can CC be taught and learnt as "*powerful knowledge"*? (Young, 2013, p. 108).

Conclusion

Curricula documents are critically important as policy manifestations of the values and priorities of educational practices (Rickinson & McKenzie, 2021). The role of CC in the curriculum can no longer be ignored. Cross-curriculum inclusion of CC education does not work for a range of theoretical and practical reasons outlined in this paper. Certain curriculum theories are hindering effective inclusion of CC in the curriculum. Particularly worth noting is the gap between the current popularity of the competencies-based curriculum trend, and its theoretical baselessness and lack of justification by evidence (Sweller et al., 2019).

If we wish our children to be effectively educated about CC then we need to move back to curricular frameworks that are receptive to disciplinary-subjects. This inevitably will require extensive efforts and resources by all the relevant stakeholders. While these challenges may

seem insurmountable, they are essential to no less degree than the essentiality to transition the world into zero emissions.

Finally, the discipline of CC has been incrementally building up and establishing itself over the past century. It is finally time, and well overdue, to introduce CC as a core high-status disciplinary-subject in the curriculum.

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